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Foreign Commodity Production Forecasting

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**A Joint Program for
Agriculture and
Resources Inventory
Surveys Through
Aerospace
Remote Sensing**

September 1981

SELECTION OF THE AUSTRALIAN INDICATOR REGION

C. R. Reed

This draft document consists of technical working material that has not been formally reviewed. It has been prepared in this manner in order to provide timely documentation to personnel supporting the Foreign Commodity Production Forecasting project of the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing program and to provide others in the technical community with a means of staying informed of project tasks.

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16. Abstract The Australia Wheat Indicator Region has been selected to support the Australia Wheat Exploratory Experiment within the Foreign Commodity Production Forecasting project of the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing program. Each state in Australia is examined for the availability of Landsat data, yield and production statistics, crop calendars, and other ancillary data. The selection of the indicator region is based on the highest wheat producing states, determined from available Australian crop statistics. This document describes the indicator regions and their uses. The selected Australia Wheat Indicator Region contains the states of New South Wales and Western Australia.					
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SELECTION OF THE AUSTRALIA INDICATOR REGION

Job Order 72-414

This report describes activities associated with the Australia experiment of the Foreign Commodity Production Forecasting project of the AgRISTARS program.

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For

Earth Resources Applications Division
Space and Life Sciences Directorate
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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PREFACE

The Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing is a multiyear program of research, development, evaluation, and application of aerospace remote sensing for agricultural resources, which began in fiscal year 1980. This program is a cooperative effort of the U.S. Department of Agriculture, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration (U.S. Department of Commerce), the Agency for International Development (U.S. Department of State), and the U.S. Department of the Interior.

The work which is the subject of this document was performed within the Earth Resources Applications Division, Space and Life Sciences Directorate, at the Lyndon B. Johnson Space Center, National Aeronautics and Space Administration. Under Contract NAS 9-15800, personnel of Lockheed Engineering and Management Services Company, Inc., performed the tasks which contributed to the completion of this research.

CONTENTS

Section	Page
1. INTRODUCTION.....	1-1
1.1 <u>INDICATOR REGION</u>	1-1
1.2 <u>AUSTRALIA WHEAT INDICATOR REGION</u>	1-2
2. SUMMARY.....	2-1
3. DESCRIPTION OF THE SELECTED INDICATOR REGION.....	3-1
3.1 <u>GENERAL CHARACTERIZATIONS OF WHEAT IN THE INDICATOR REGIONS, WITH POTENTIAL PROBLEMS ANTICIPATED FOR PROPORTION ESTIMATION</u>	3-1
3.2 <u>CONFUSION CROPS</u>	3-4
3.3 <u>FIELD SIZE DISTRIBUTION</u>	3-5
3.4 <u>CROP CALENDAR</u>	3-5
3.5 <u>CROPPING PRACTICES</u>	3-11
3.6 <u>ACQUISITION TIME PERIODS</u>	3-21
3.7 <u>LANDSAT DATA AVAILABILITY</u>	3-21
3.8 <u>GROUND OBSERVATIONS IN AUSTRALIA</u>	3-27
3.9 <u>RELATIONSHIPS OF CLIMATE TO LABELING ACCURACY AND PROPORTION ESTIMATION</u>	3-29
Appendix	
A SOURCES OF DATA.....	A-1
B WHEAT VARIETIES.....	B-1
C DISEASES AND PESTS COMMON TO NEW SOUTH WALES, AUSTRALIA.....	C-1
D WESTERN AUSTRALIA WHEAT GROWING REGIONS AND NEW SOUTH WALES CEREAL GROWING REGIONS.....	D-1
E REFERENCES.....	E-1

TABLES

Table		Page
1-1	AUSTRALIAN CROP STATISTICS FOR WHEAT.....	1-3
2-1	SUMMARY OF CHARACTERISTICS STUDIED IN THE INDICATOR REGION.....	2-2
3-1	ESTIMATED AREAS OF IRRIGATION IN NEW SOUTH WALES.....	3-14
3-2	1977-78 TRANSITION YEAR ESTIMATES.....	3-24
3-3	SUMMARY OF LANDSAT SEGMENT DATA.....	3-25
3-4	GROUND OBSERVATIONS, AUSTRALIA.....	3-28

FIGURES

Figure		Page
1-1	Australian Wheat Indicator Region.....	1-5
1-2	Australian wheat regions.....	1-6
3-1	Map of Australia showing major climatic zones.....	3-2
3-2	Crop calendar for New South Wales.....	3-6
3-3	Crop calendar for Western Australia.....	3-8
3-4	Australian small grains 185-day crop calendar for 1977-78.....	3-10
3-5	Simplified soil map of the wheat belt of Western Australia.....	3-22
3-6	Australian full frames, 1980-81.....	3-26
3-7	Stress area delineated by GIN.....	3-30
3-8	Areas of rainfall deficiencies.....	3-31
B-1	1979 silo groups in New South Wales with shire boundaries.....	B-2
D-1	Wheat growing regions in Western Australia.....	D-2
D-2	Map showing the eight agricultural regions of New South Wales.....	D-3

1. INTRODUCTION

The Foreign Commodity Production Forecasting (FCPF) project is one of eight major projects within the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS) program. The objectives of the FCPF project are specified in the AgRISTARS Technical Report Plan (ref. 1):

The overall objective of the FCPF project is to develop technology for making improved production forecasts in foreign areas. Such technology will be evaluated by the USDA for possible integration into its crop information systems.

The specific objective of the FCPF project is to develop and test procedures for using aerospace and related technology to provide more objective and reliable crop production forecasts several times during the growing season and to provide improved preharvest estimates for a range of countries and crops.

The purpose of this report is to document the region selected for study in Australia and describe its characteristics which influence the performance of crop information systems.

1.1 INDICATOR REGION

The experiment design for the FCPF project of the AgRISTARS program requires the identification of foreign areas of interest for exploratory experiments and pilot tests. Full foreign country production or area estimation is not within the scope of the experiment; therefore, indicator regions (IR's) that are representative of important production areas are needed. After the selection of an IR, Foreign Similarity Regions (FSR's) in the United States will be chosen based on the similarity of conditions to the foreign IR*. To aid in the selection of the FSR, the following conditions associated with the IR were studied:

- a. Highest amounts of production for crops of interest
- b. Representative crop varieties and cropping practices encountered throughout the foreign country
- c. Agronomic trends affecting national production

*Similar regions in the United States are needed because of the available or potentially available ground observations and other data resources.

The FSR will be used as a testing region for development of techniques which permit estimation of error in area estimation. These techniques will support accuracy assessment for the IR during FCPF project exploratory and pilot experiments. Other uses of the FSR may be to support development of area estimation procedures, sensitivity studies for both segment-level and aggregated area estimation performance, plus simulation modeling of state-of-the-art crop inventory systems.

This report describes the FCPF project IR selected for Australia. This information is to be used to aid in selecting an appropriate FSR in the United States.

1.2 AUSTRALIA WHEAT INDICATOR REGION

The Australian Wheat Indicator Region (fig. 1-1) has been selected to support the Australia Wheat Experiments within the FCPF project of the AgRISTARS program. The IR was selected primarily on the basis of highest production for the Australian states. Each Australian state was examined for the availability of Landsat data, area, yield and production statistics, crop calendars, and other ancillary data. The IR is reviewed according to agrophysical conditions that could influence labeling and classification accuracies. Therefore, these conditions were identified in connection with the highest producing states as determined from available Australian crop statistics (table 1-1).

As shown in figure 1-2, wheat production is concentrated in a broad belt that extends from the vicinity of Adelaide in South Australia, into Victoria, north through New South Wales, along the rim of the Murray Basin, and into southern Queensland. Wheat is also produced in Western Australia in the area east of Perth, to the north and south (fig. 1-2). Based primarily on the production statistics, the final IR's for wheat are the state of Western Australia and New South Wales.

TABLE 1-1.- AUSTRALIAN CROP STATISTICS FOR WHEAT

a. Production statistics
(in thousands)

States of interest	5-Year annual average production, 1971-72 to 1975-76		10-Year annual average production, 1966-67 to 1975-76	
	Metric tons (1000)	Total*, %	Metric tons (1000)	Total*, %
New South Wales	3 289	32	3 763	36
Western Australia	3 155	31	2 933	28
Victoria	1 691	16	1 691	16
South Australia	1 338	13	1 350	12
Queensland	635	6	656	6
Total	10 108	†98	10 393	†98

b. Area statistics

States of interest	Area planted in wheat, 5-year annual average, 1971-72 to 1975-76		Area planted in wheat, 10-year annual average, 1966-67 to 1975-76	
	Hectares	%*	Hectares	%*
New South Wales	2 669 373	32	2 929 524	34
Western Australia	2 687 678	33	2 675 722	31
Victoria	1 119 960	13	1 188 188	14
South Australia	1 133 077	13	1 164 062	13
Queensland	497 203	6	524 665	6
Total	8 107 291	†97	8 482 161	†98

*Total national wheat production.

†Australian Capital Territory and Tasmania and the North Territory not included.

TABLE 1-1.- Concluded.

c. Yield statistics
(metric tons/hectares)

States of interest	5-Year annual average, 1971-72 to 1975-76	10-Year annual average, 1966-67 to 1975-76
New South Wales	1.22	1.28
Western Australia	1.15	1.09
Victoria	1.47	1.41
South Australia	1.16	1.14
Queensland	1.27	1.22
Total	1.23	1.22

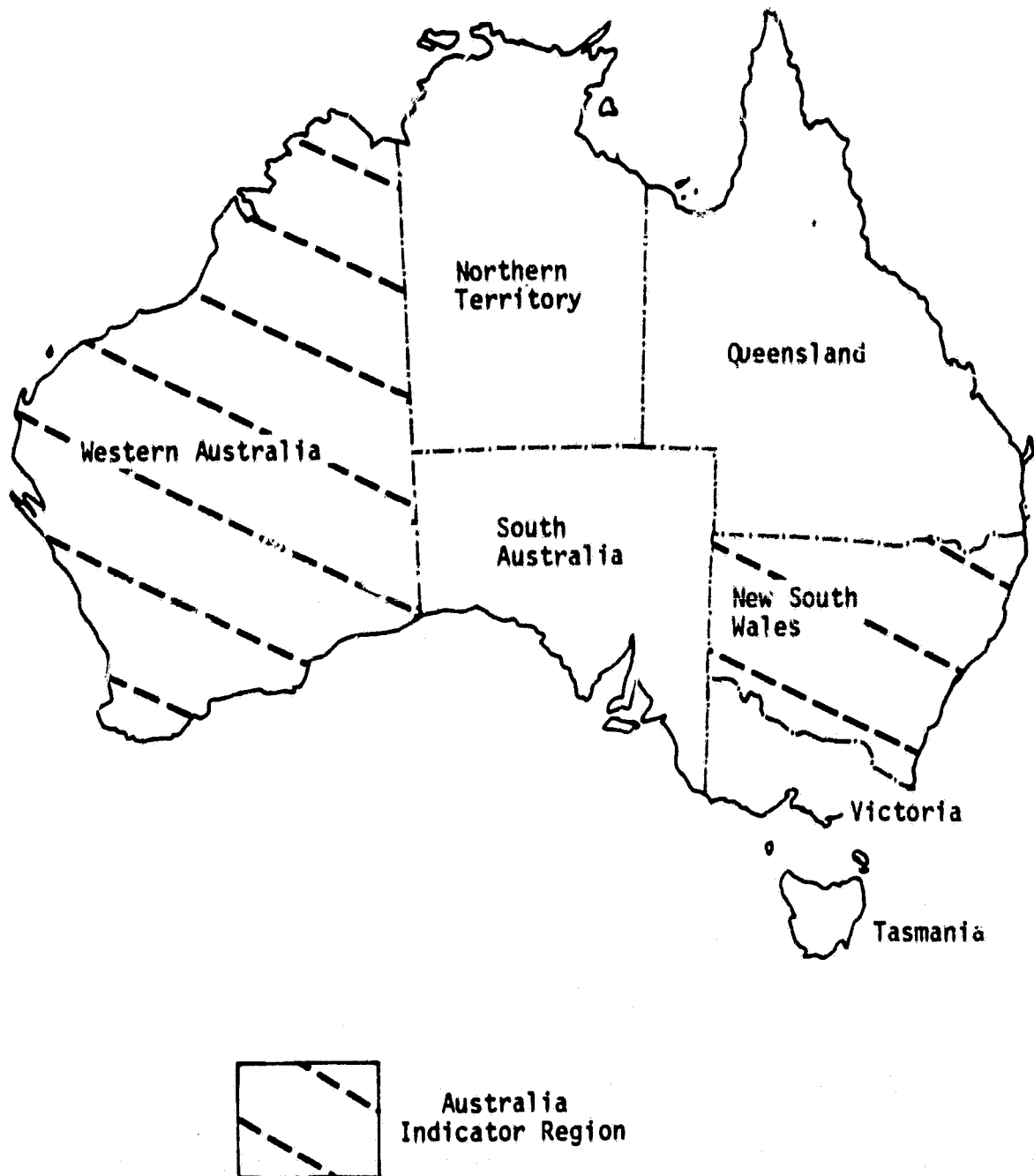


Figure 1-1.- Australian Wheat Indicator Region.

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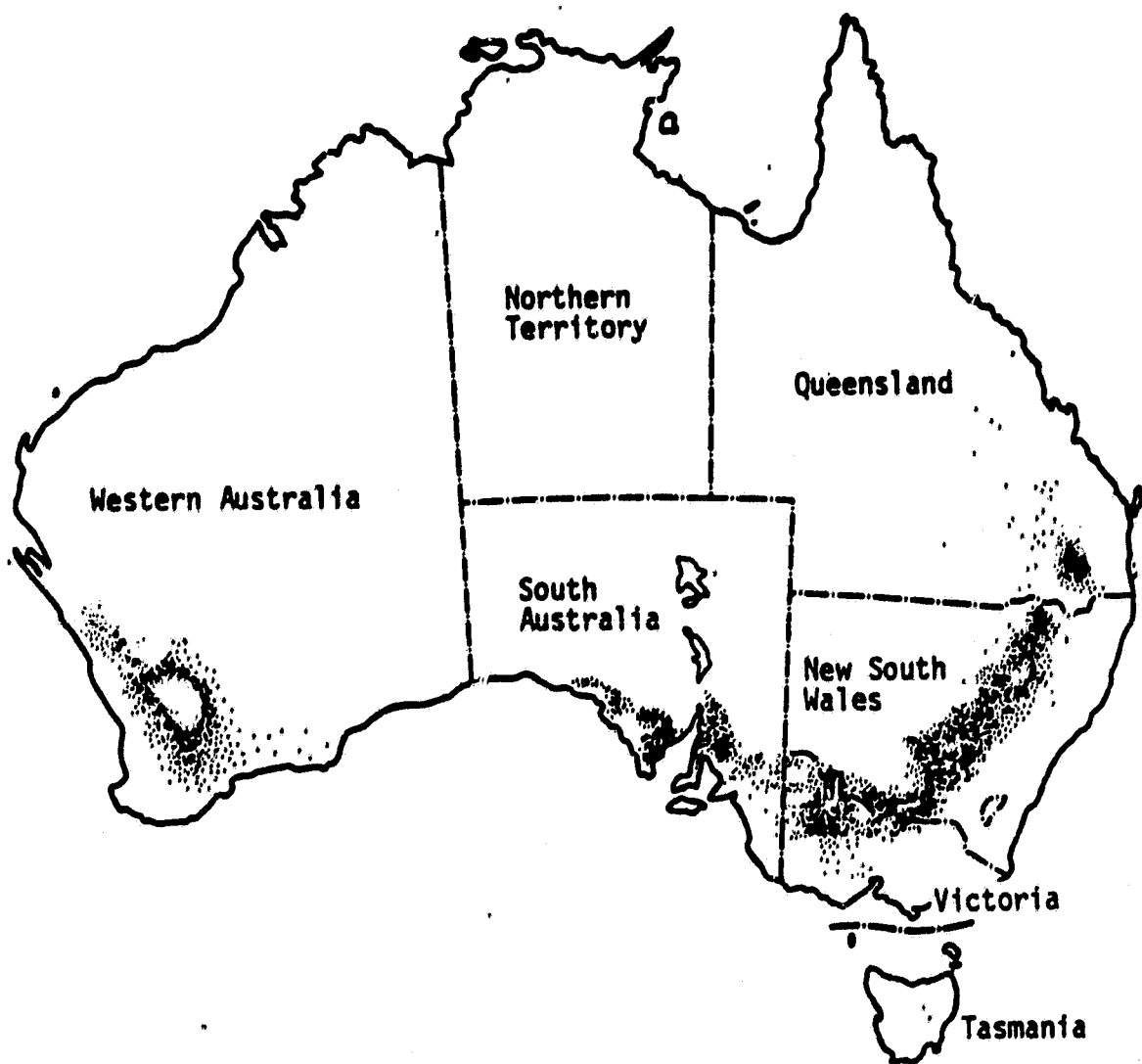


Figure 1-2.- Australian wheat regions.

In general, agricultural statistics for Australia are published at various times on a yearly basis. The final statistics for a particular crop year are published 1 to 9 months after harvest. The FCPF project has prepared a statistical data base containing available statistics for 1969-70 to 1976-77 for Australian wheat and confusion crops at the shire (corresponds approximately to a U.S. county) level.

2. SUMMARY

The IR was chosen to represent major crop production areas in the foreign country. The Australia IR is composed of the states of Western Australia and New South Wales. These states will represent the Australian Wheat IR in support of the Australian Wheat Exploratory Experiment. Combined, these states produced 63 percent of the country's wheat (table 1-1) and contained 65 percent of the area planted in wheat (table 1-1).

Limited ground observations in Australia are presently available. Subsequently, FSR's in the United States with available or potentially available ground observations will be selected based on the similarity of conditions to the IR.

The FSR will be used in error characterization, for segment-level and aggregated area estimation performance to improve area estimation procedures, for sensitivity studies, and for simulation modeling of state-of-the-art crop inventory systems.

A summary of the characteristics of the Indicator Region selected are presented in table 2-1.

TABLE 2-1.- SUMMARY OF CHARACTERISTICS STUDIED IN THE INDICATOR REGION

Item	Characteristics
General characterization of wheat in the Indicator Region (p. 3-1)	Ley-farming system used (p. 3-1). Winter wheat is grown, but varieties have spring growth habits. It is sown in the fall season. Active growth occurs even through winter. Region for wheat is semi-arid, 250-500 mm rainfall. In New South Wales there is no pronounced seasonal distribution of rainfall in the south, but the north has a summer maximum/winter minimum cycle. In Western Australia there is a pronounced winter maximum (June - Sept.). Forty percent of the wheat in Western Australia is from areas with less than 325 mm.
Problems anticipated in proportion estimation	Abandonment (p. 3-3), confusion in wheat signature (p. 3-3), post-harvest green-up (p. 3-4), crop calendars (long growth-stage lengths) (p. 3-5), phenological development of other crops (p. 3-4).
Confusion crops (p. 3-4)	Improved and natural pasture, barley, oats.
Field size (p. 3-4)	Rectangular in shape. In older developed areas, fields are smaller, like those of Eastern Kansas. In newer areas, fields can be as large as some fields in the U.S.S.R. spring wheat region.
Crop calendars (p. 3-5)	State level only. Interpolated growth stages (of which long growth stages are a result) probably do not account for late-planted varieties.
Cropping practices	Varieties (p. 3-11):
	Change yearly. Recommendations are made each season. Early and late season varieties are planted.
	Irrigation (p. 3-13):
	No information for Western Australia. In New South Wales, most is for higher valued crops: rice, cotton. Areas: central, north, northwestern regions, in New South Wales.

TABLE 2-1.- Continued.

<u>Item</u>	<u>Characteristics</u>
Cropping practices (continued)	<p>Erosion control (p. 3-13):</p> <p>Strip cropping in the northwest slopes and plains of New South Wales.</p> <p>Fertilizers:</p> <p>New South Wales (p. 3-15): superphosphate, nitrogen, and leguminous rotations.</p> <p>Western Australia (p. 3-15): phosphorous, trace elements, and nitrogenous fertilizers, and leguminous rotations.</p> <p>Disease and pests:</p> <p>New South Wales (p. 3-16): Take all, stem rust, powdery mildew, flag smut, rabbits, locusts, kangaroos, noxious weeds, and wild oats.</p> <p>Western Australia (p. 3-17): Septoria, take all, stem rust, earth mites, weavils, webworm, wild oats.</p> <p>Minimum tillage (p. 3-19):</p> <p>Only 10-15% of the total cropped area in Western Australia. Confined to a portion of heavier soils.</p> <p>Crop rotations (p. 3-19):</p> <p>Wheat, barley, or oats, 2 out of 5 years. Ley farming system rotated with natural and leguminous pastures.</p> <p>Western Australia (p. 3-21):</p> <p>Range from heavy clays to fertile, loamy soils, to infertile sands.</p>
Soils	

TABLE 2-1.- Concluded.

<u>Item</u>	<u>Characteristics</u>
Acquisition time periods for discerning wheat and small grains (p. 3-21)	Preplanting to pre-emergence (late March to early May). Early mid-season varieties emerging (late June to late July). Late planting, after emergence (mid-Sept. to late October). Turning (late Oct. to early Nov.). Harvest (mid Nov. to late Dec.)
Landsat data availability (p. 3-21)	1975-1976: Exploratory sites in limited number. Aug. 1977-Jan. 1978: 257 segments throughout Australia, early growth period missing. 1979-80 season: 257 segments throughout Australia. 1980-81 season: subset of the country. New South Wales and Western Australia to support an Indicator Region approach. 1981-82 season: subset of the country. New South Wales and Western Australia to support an Indicator Region approach. 16 segments more than in the 1980-81 season.

3. DESCRIPTION OF THE SELECTED INDICATOR REGION

3.1 GENERAL CHARACTERIZATION OF WHEAT IN THE INDICATOR REGIONS, WITH POTENTIAL PROBLEMS ANTICIPATED FOR PROPORTION ESTIMATION

Within the wheat producing areas commonly referred to as commercial crop areas, a rotation system exists, with sheep and wheat sharing the land. This system is referred to as "ley farming," and it involves a sequence of cropping for 1 or 2 years after several years of maintaining fertility-building pasture. The pastures are planted in leguminous plants such as subterranean clover. Leguminous plants help build up the soil's organic matter, extend the moisture-holding capacity, and increase the amount of nitrogen available for crops (ref. 2). Usually after several years, it is then plowed and returned to wheat cultivation. Overall, the land is productive, but the wheat yields are low compared to American standards.

Wheat grown in Australia principally consists of varieties which have spring growth habits. These varieties are sown in late May or early June after the rains, during the Southern Hemisphere's fall season; winter temperatures are sufficiently mild, promoting active growth even through July and August. As indicated in the sketch below, heading normally occurs during October, with harvest in late November and December, though in some years harvest carries through January. The regions where wheat is grown are semiarid with an average

		Break-of- season plowing											
Dry pasture/ grasses/clover		Wheat planting		Wheat growth		Wheat senes- cence		Wheat harvest					
Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		

annual rainfall of about 250-500 mm. The more recent available statistics indicate that very little wheat area is irrigated (ref. 3). The wheat varieties grown are bred for dry conditions. Most irrigation is reserved for the higher valued crops such as rice and cotton.

The climatic regions in which wheat is grown have normal annual precipitation totals which are similar to each other, but the usual distribution of monthly

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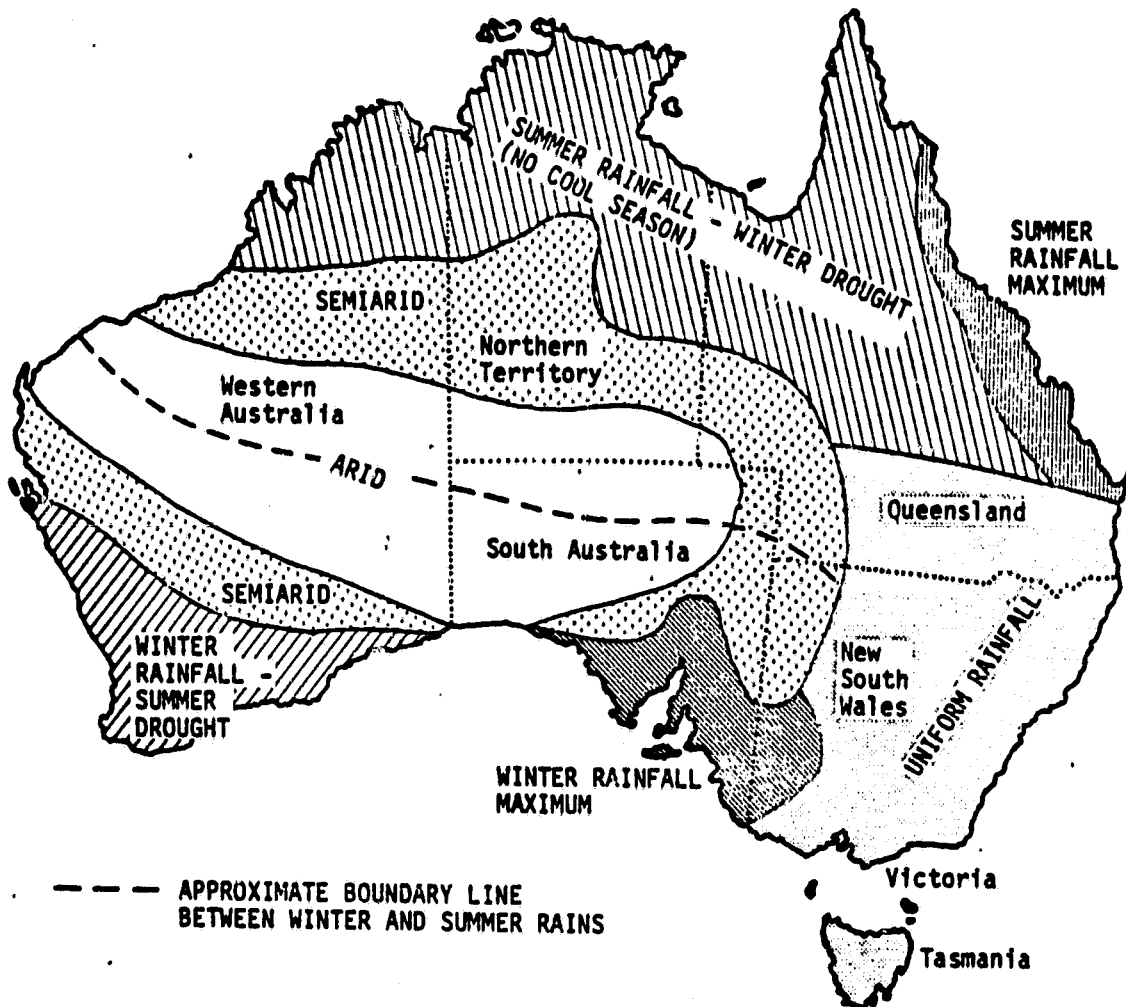


Figure 3-1.- Map of Australia showing major climatic zones.
These zones are based mainly on rainfall.

amounts varies considerably. In Western Australia, there is a pronounced maximum winter precipitation, with most of the rainfall occurring from June through September when the wheat is actively growing. Rainfall shifts to a balanced distribution in the southern part of New South Wales, shifting again to a summer maximum precipitation (fig. 3-1) in the far northern part of New South Wales and into Queensland. In the northern part of New South Wales, rainfall occurs principally from November to February prior to seeding. To meet its water requirements, the wheat crop in these areas is dependent on stored pre-season moisture as well as rain showers during the growing season. Drought is an occurrence in some years.

In Australia, the usual sequence of wheat development and concurrent weather is significantly different from that experienced by spring wheat varieties in the Northern Great Plains of the United States. The Australian wheat crop is established and continues to grow during the cool months when moisture demand is minimal. The heading and grain-filling period occurs during the spring, prior to the stress of high mid-summer temperatures. Therefore, the plant usually progresses through much of its critical growth period without major stress. In contrast, U.S. spring wheat varieties are sown at a time of rising temperatures and normally experience midsummer heat and moisture stress during the critical flowering and filling stages (ref. 4).

Potential problems for proportion estimation can be described as follows.

a. Abandonment:

Wheat is planted in the dry margins of the Western Australia Wheat belt each year, even though the risk is great. Abandonment occurs each year in the outback region. Abandonment can occur as early as just after sowing. In some years, when the rains are late, preplanting procedures are delayed and a late crop may not be able to be resown if it fails. Abandonment then can occur at any time; i.e., after planting, because the crop did not germinate, or at any other time until harvest.

During the Transition Year (TY) processing there was uncertainty regarding harvest signatures. For example, several fields within a segment exhibited

definite harvest or harvest-in-progress signatures, whereas nearby potential small-grain fields showed little or no change after the initial senescence period. The question with respect to these fields was "harvest or abandoned?" This will remain one of the major labeling issues to be resolved (ref. 5).

b. Post-harvest green-up:

Pasture can be sown in the wheat crop so that after the wheat is harvested the pasture remains. Clovers are capable of reseeding themselves in the harvested wheat field, resulting in a post-harvest green-up.

c. Crop calendars:

No crop calendars have been developed at this time to incorporate the short-growth wheat varieties and to portray the great range in crop stage at any one given time.

d. Phenological development of other crops that are similar to wheat¹:

Improved pastures and natural grasses display a phenological development sequence similar to wheat, and spectral confusion is possible. A break of season (plowing) occurs prior to wheat planting when the natural grasses (weeds) are plowed several times for weed control. This is the best period for separating wheat from the natural grasses and improved pastures.

3.2 CONFUSION CROPS

For Australia, the most common confusion crops are barley and oats. Although rye, which has the same characteristics, is grown to a limited extent in Australia, it is not used for grain purposes but is used to control soil erosion in sandy areas. Wheat, barley, and oats may be inseparable with only 18-day coverage and with crop calendar data and classification procedures which are available at this time. Without the proper acquisition history, improved pastures and natural grasses have a phenological development similar to wheat and spectral confusion is possible in the classification of small grains (ref. 6).

¹According to Drs. Smith and Beeg, Australian scientists.

3.3 FIELD SIZE DISTRIBUTION

The older, more established, wheat-growing areas tend to have smaller field sizes, and the newer, more recently expanded wheat-growing areas are larger. For the most part, the fields are rectangular or rectilinear. Eastern Australia, of which New South Wales is a part, has field sizes similar to those of central and eastern Kansas 198-395 hectares (80-160 acres). In Northern New South Wales near the Queensland border (Booolooroo shire) and in Western Australia, field sizes are similar to the large fields in the spring wheat region of the U.S.S.R. 494-1976 hectares (200-800 acres). In general, field sizes are not anticipated to be a major problem.

3.4 CROP CALENDARS

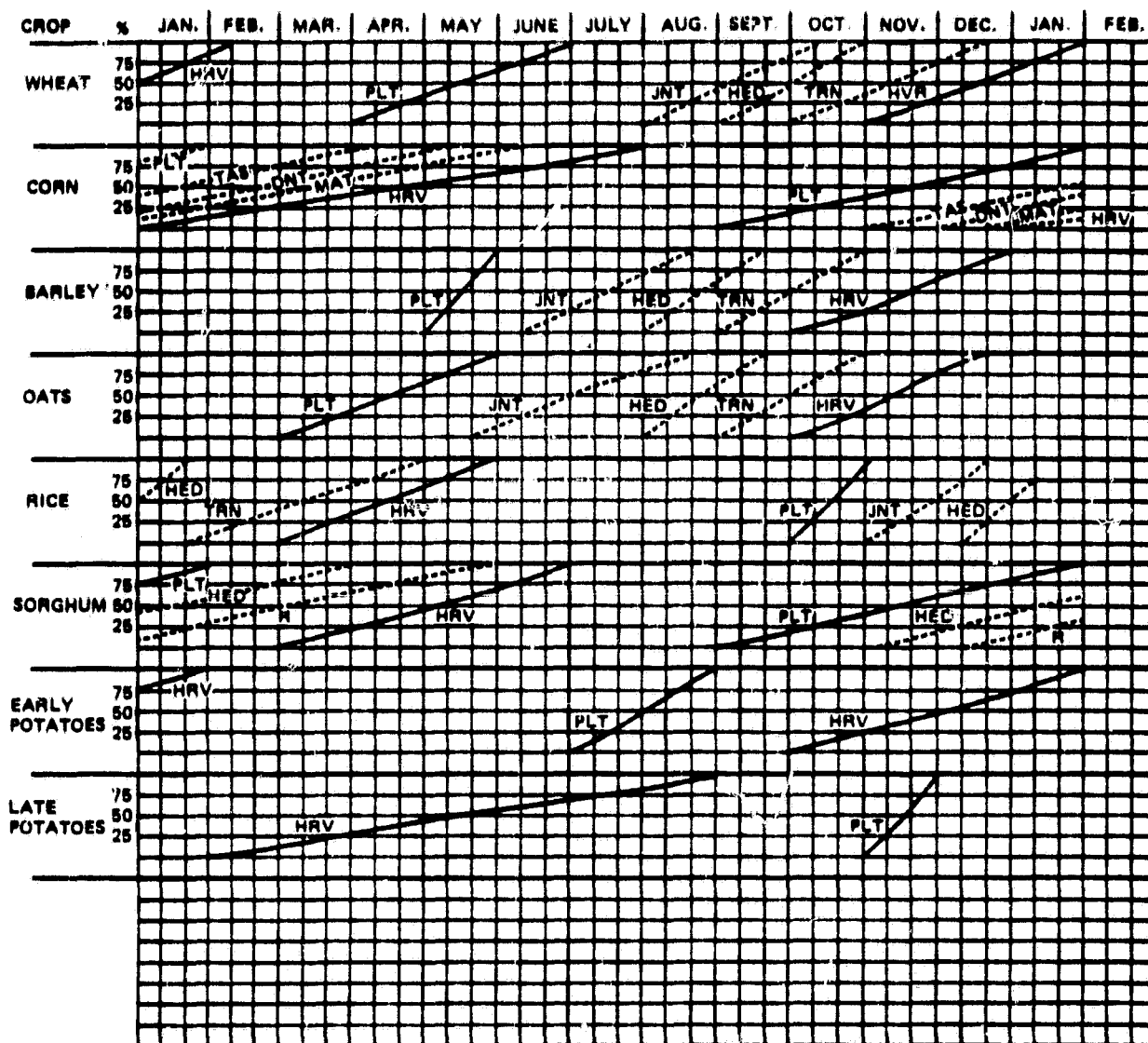
The historical crop calendars (ref. 7) are available at a state level only, with a range of planting and harvesting dates reported. Interpolation of the other crop growth stages was based on climatic factors. These calendars were developed by the LACIE Regional Analysis section in 1975 and were based on Australian crop data for periods prior to 1974 (figs. 3-2 and 3-3).

Adjusted crop calendars were developed by the National Oceanic and Atmospheric Administration (NOAA), and were based on the then current meteorological data for the 1977-78 growing season. At the start of processing the 1977-78 crop season data, it was noted that the historical and adjusted crop calendars did not reflect the growth stage as interpreted from the Landsat imagery. Image analysts indicated that they believed plant growth was ahead of both the adjusted and the historical crop calendars.

To compensate for this discrepancy, the Classification and Mensuration Subsystem (CAMS) analysis team developed a 185-day crop calendar (planting to harvest). It was felt at the time of TY processing that this crop calendar best reflected the small-grains growth stages for Australia in the 1977-78 crop year. This "spectral crop calendar" was developed for all TY segments processed for an estimate in Australia (fig. 3-4). With further evaluation of TY (1977-78) processing, it has been determined that this crop calendar does not account for late

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CROP CALENDARS PLOTTED 1960-1970
PERCENT OF AREA IN DEVELOPMENT STAGE BY SPECIFIED DATE FOR
New South Wales, Australia (Rural Industries, 1969-70, Bulletin No. 8)



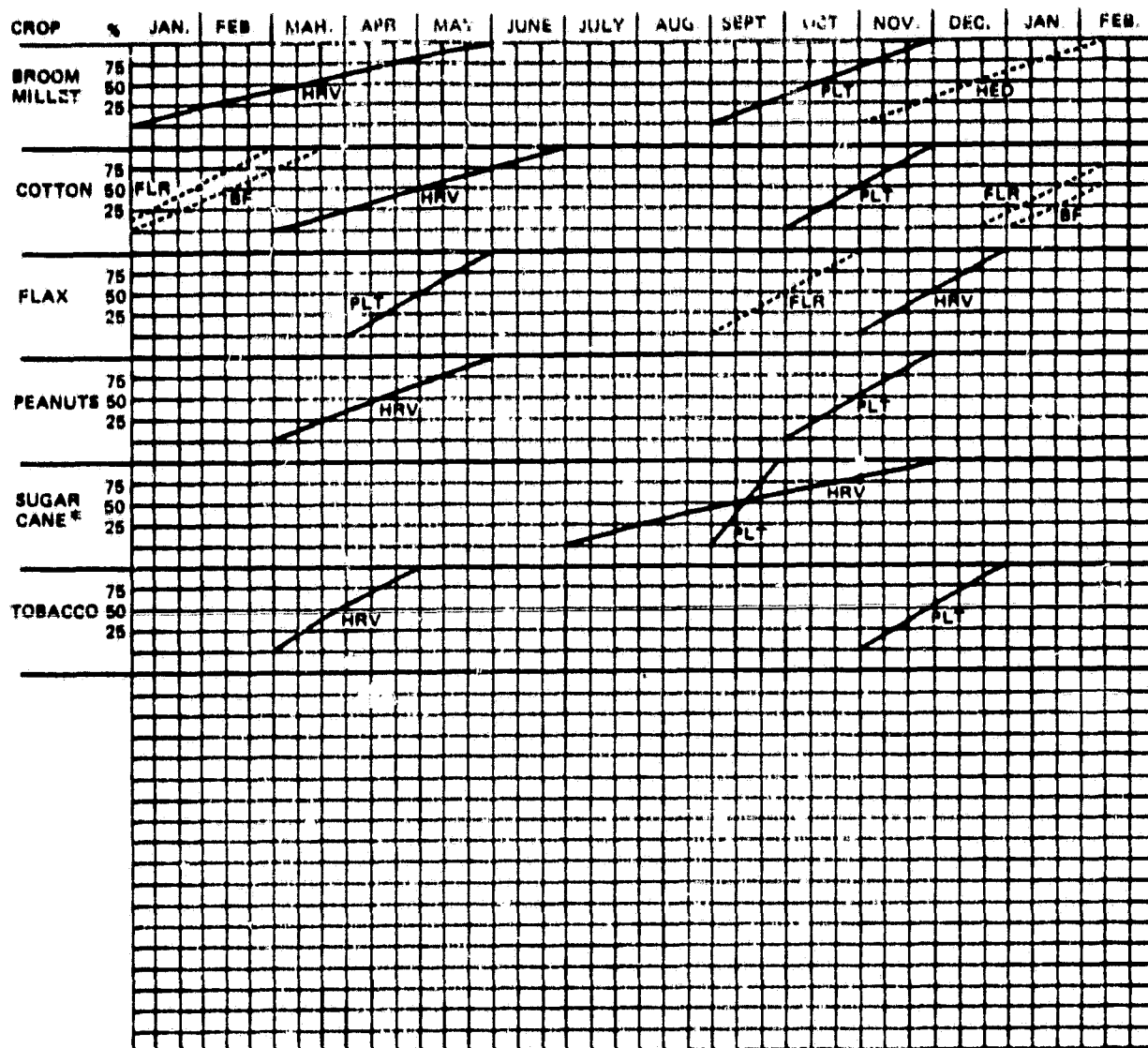
LEGEND

BF	Bolt formation
DNT	Denting
E	Under stage name, indicates rough estimate of date
FLR	Flowering
HED	Heading
HRV	Harvest
JNT	Jointing
MAT	Mature
PLT	Planting
R	Ripening
TAS	Tasseling
TRN	Turning

Figure 3-2.- Crop calendar for New South Wales, Australia.

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CROP CALENDARS PLOTTED 1969-1970
PERCENT OF AREA IN DEVELOPMENT STAGE BY SPECIFIED DATE FOR
New South Wales, Australia (Rural Industries, 1969-70, Bulletin No. 8)



*First harvest is 24 months after planting.

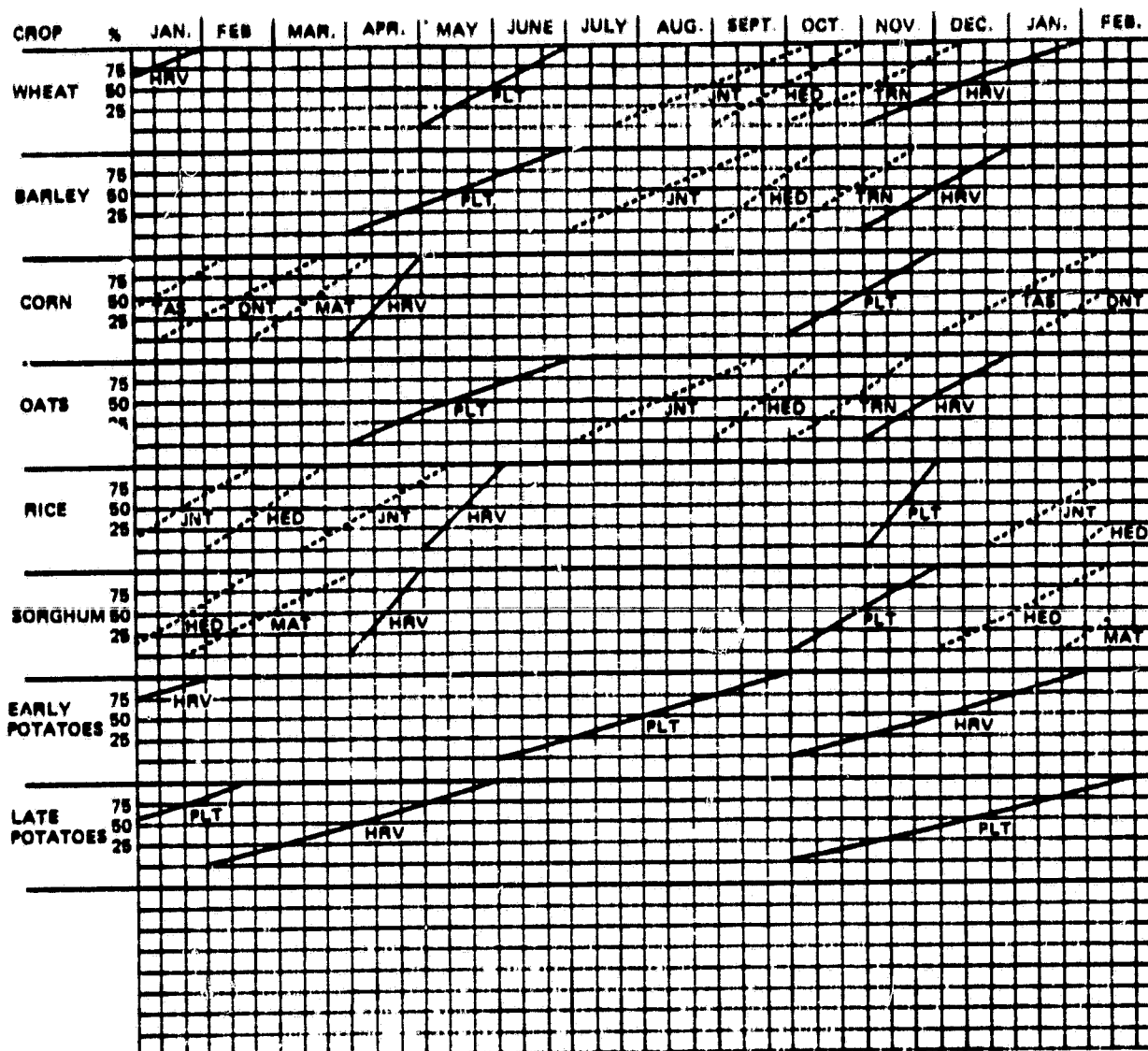
LEGEND

BF	Boil formation
ONT	Denting
E	Under stage name, indicates rough estimate of date
FLR	Flowering
HED	Heading
HRV	Harvest
JNT	Jointing
MAT	Mature
PLT	Planting
R	Ripening
TAS	Tasseling
TRN	Turning

Figure 3-2.- Concluded.

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CROP CALENDARS PLOTTED 1966-1970
PERCENT OF AREA IN DEVELOPMENT STAGE BY SPECIFIED DATE FOR
Western Australia (Rural Industries, 1966-70, Bulletin No. 8)



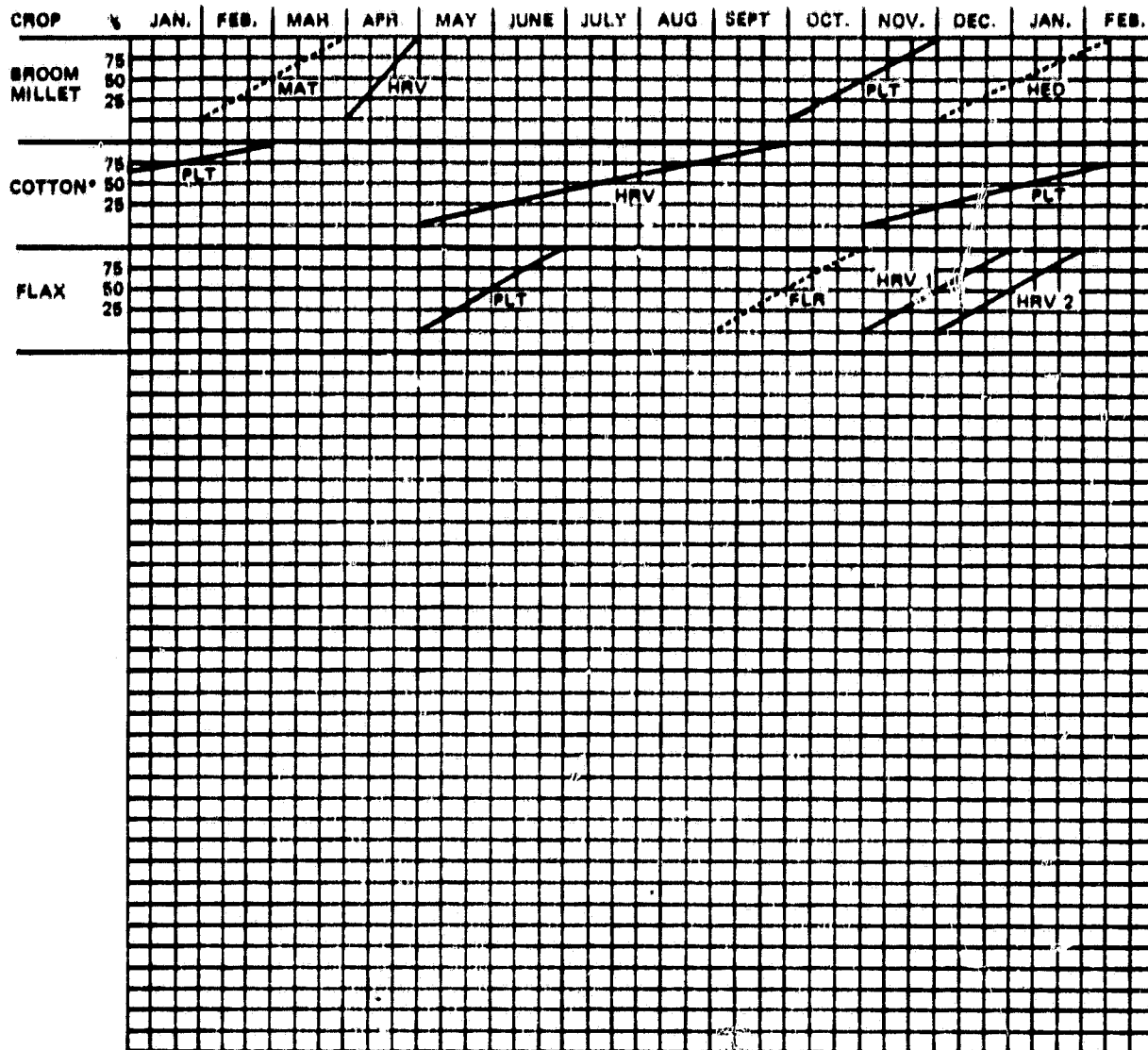
LEGEND

BF	Bolt formation
ONT	Denting
E	Under stage name, indicates rough estimate of date
FLR	Flowering
HED	Heading
HRV	Harvest
JNT	Jointing
MAT	Mature
PLT	Planting
R	Ripening
TAS	Tasselling
TRN	Turning

Figure 3-3.- Crop calendar for Western Australia.

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CROP CALENDARS PLOTTED 1960-1970
PERCENT OF AREA IN DEVELOPMENT STAGE BY SPECIFIED DATE FOR
Western Australia (Rural Industries, 1969-70, Bulletin No. 8)



*Cotton may be harvested twice from a single planting.

LEGEND

BF	Boll formation
DNT	Denting
E	Under stage name, indicates rough estimate of date
FLR	Flowering
HED	Heading
HRV	Harvest
JNT	Jointing
MAT	Mature
PLT	Planting
R	Ripening
TAS	Tasseling
TRN	Turning

Figure 3-3.- Concluded.

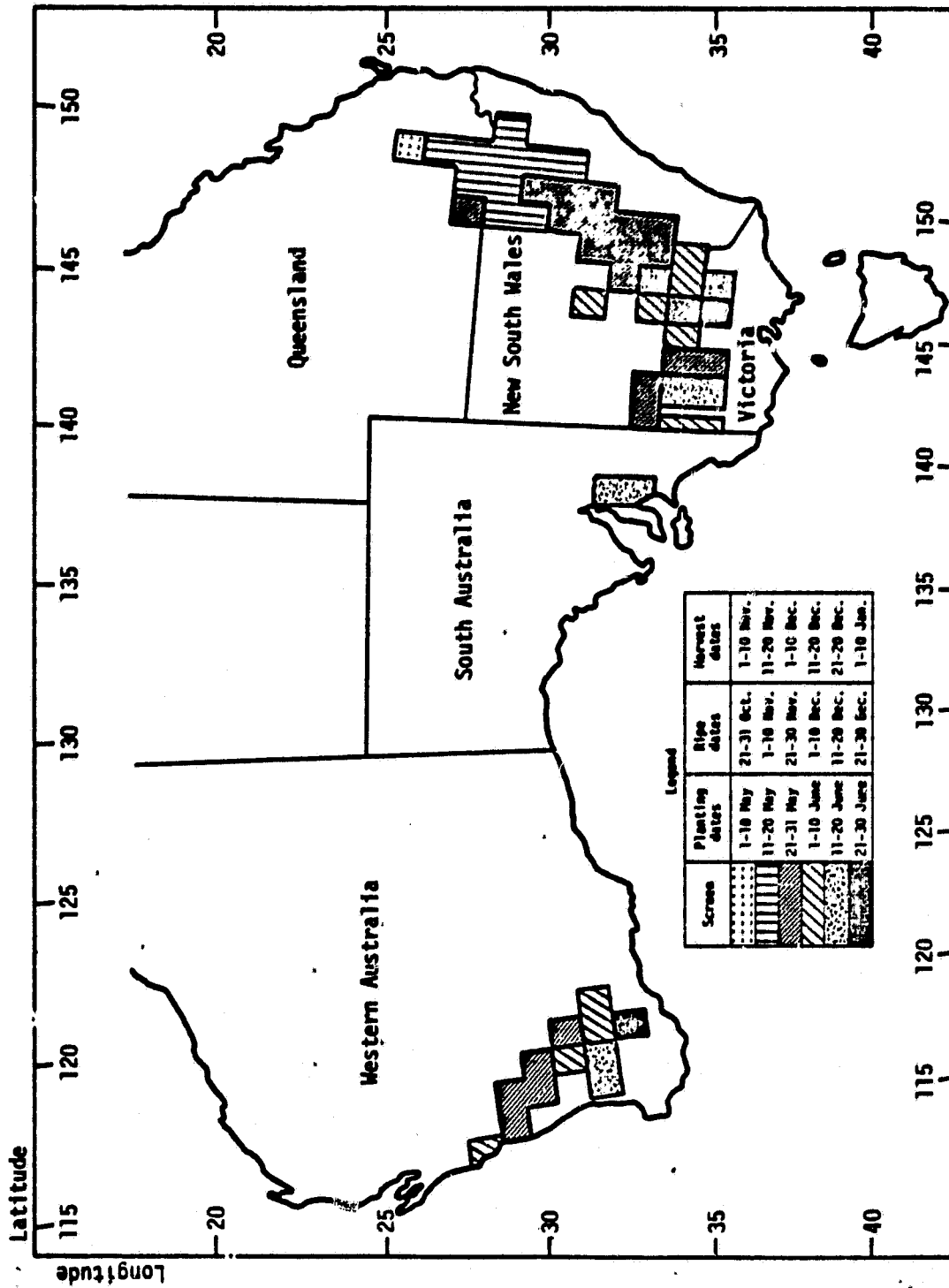


Figure 3-4.- Australian small grains 185-day crop calendar for 1977-1978.

planted wheat varieties. However, the historical crop calendars fail here also. This is a potential problem for procedures development in processing Australian data.

In the summer of 1976, Professor Phillip Bacon from the Geography Department of the University of Houston, in Houston, Texas, corresponded with agronomy departments and state governmental organizations in Australia in an effort to update the historical crop calendar information (refs. 8 and 9). Some data of a general nature were obtained.

Short-growth (i.e., late planted and thus shorter season) wheat varieties account for approximately 20 percent of the wheat production in New South Wales (ref. 10). It is these short-growth varieties that are not represented on the historical crop calendar, or the 185-day calendar (ref. 11).

Additional crop calendar data are needed at a smaller level than state, and adjustments need to be made for the different types of wheat varieties. Literature is now available which documents the planting period for the various varieties in New South Wales and Western Australia in terms of early-season-to-midseason- and late-season wheat varieties. This information should be useful for updating the normal crop calendars.

3.5 CROPPING PRACTICES

3.5.1 VARIETIES

Wheat and other small grains are usually planted at about the same time in late May through June. They are then harvested from late November through December, and, in some years, through January (figs. 3-2, 3-3, and 3-4). Short-growth wheat varieties are grown throughout the dry margins. Australian varieties are bred for dry conditions.

Each year in Western Australia, recommendations for grain crop varieties are made based on a wide testing program sponsored by the Department of Agriculture. Some 8,000 plots are sown on 60 trial sites throughout farming

areas to compare varieties. New varieties are compared with commercial varieties; grain quality as well as yield is considered before recommendations are finalized. Proposals for recommendations and the release of new wheat varieties are submitted to the State Wheat Advisory Committee. Proposals for grains other than wheat are submitted to the State Coarse Grains and Seeds Advisory Committee. These committees (which include grower, marketing, and grain-handling representatives) examine the proposals before final recommendations are released.

Recommendations for wheat varieties to be sown each year are given according to grades. The Australian Standard White (ASW) is the main grade received at most sidings. Australian Hard and Australian Soft are produced in specific areas and are received only at sidings nominated each year by the Australian wheat board. A description of each variety for the 1979 season, including two new varieties, is included in appendix B (ref. 12).

In New South Wales, wheat variety recommendations are formulated after examination of marketing, handling, and varietal information and are based on agreement among the wheat growers' organizations, the Grain Elevator Board of New South Wales, the Australian Wheat Board, the flour millers and stockfeeders associations, and the wheat breeding organizations. The recommendations are reviewed by the New South Wales Standing Advisory Committee on Wheat. In varietal control, the main aims are to reduce the need for unnecessary segregation in bulk storage, enhance the specification of existing and potential wheat grades, and give greater flexibility in matching the inherent qualities of varieties to the special needs of grain users. Three major components are studied to formulate the new recommendations: varieties available (either currently in use or developed to a stage for rapid seed increase); the protein content of the grain at each silo; and the silo facilities available for segregation. Appendix B includes a listing and discussion of the recommended varieties with respect to silo groupings and a map of these groupings (refs. 13, 14, and 15).

Short-growth wheat varieties account for approximately 20 percent of the wheat production in New South Wales. The short-growth varieties are grown because they are "drought escaping," that is, they mature and are harvested before the onset of drought conditions is likely. However, the varieties that require a longer period of growth are preferred since they produce higher yields. Short-growth wheat varieties are grown throughout the dry margins (refs. 6 and 10).

3.5.2 IRRIGATION OF WHEAT

Wheat is seldom irrigated since the Australian varieties are bred for dry conditions, and most irrigation is reserved for the higher valued crops such as rice and cotton.

In New South Wales the expansion areas of irrigated wheat are largely in the central and north-northwestern regions, although the total area of irrigated wheat in these areas is considerably less than in southern New South Wales (table 3-1). See references 3 and 6.

In Western Australia about 40 percent of the wheat produced comes from areas receiving less than 325 millimeters (12.8 in.) of average annual precipitation, yet the wheat is grown dryland and irrigation is used on improved pasture.

Irrigation is also used on improved pasture in New South Wales. In the 1975-76 crop season, irrigated pastures (sown and native) comprised about 282 000 hectares of the 602 550 hectares of irrigated land in New South Wales. They were predominantly winter growing types of annual rye grass and subterranean clover (ref. 16).

3.5.3 STRIP CROPPING IN CONNECTION WITH EROSION CONTROL

Erosion-control strip cropping has been identified on the Landsat imagery in small amounts in New South Wales in the slightly sloping black soil areas of the northwest slopes and plains. Soils in these areas have a high natural fertility and an extremely high water-holding capacity; but since the infiltration rate of the soils is low (3-4 mm per hour), runoff is high. Because

TABLE 3-1.- ESTIMATED AREAS OF IRRIGATION IN NEW SOUTH WALES

Area	Estimated area of irrigated wheat hectares	
	1975-76	1976-77
Macquarie Valley	10 000	16 500
Namoi Valley	9 000	13 500
Gwydir Valley	900	14 500
Coonamble District	1 500	2 500
Other	1 000	1 000
Southern New South Wales	86 000	95 000

there are extensive areas of these soils, the volume of runoff during heavy rains is very great.

Pasture improvement is one defense against soil erosion. Pastures may be sown with cereal grains which are harvested first, leaving the pastures underneath remaining.

In the past, the grazing of sheep and cattle was the main land use, so erosion was not a serious problem; however, with more land being utilized for crops each year, erosion is increasing significantly (ref. 17).

3.5.4 FERTILIZERS - NEW SOUTH WALES

Tests conducted on farmer's experiment plots indicate that benefits derived from the application of superphosphate to wheat-lands are most marked in the Southern Slope and Southern Plains agricultural areas, which comprise the southern portion of the wheat belt. The beneficial results gradually diminish in the central portion of the wheat belt, and the least advantage is gained in the heavier and phosphate bearing soils of the northwestern districts (ref. 14).

Applications of nitrogen fertilizer have greatly increased yields in many situations, but this measure provides only a short-term solution. Increased usage of leguminous-type crops is needed to replace the nitrogen in the soil. In the winter-rainfall regions of the South, a subterranean clover rotation system has been successful; however, it has not worked as well in the North where legumes do not fit in well with the established cropping practices. In wheat farming areas in which this system has been incorporated, cropping of grain legumes such as lupins, soybeans, and mung beans reveals that biologically-fixed nitrogen is both more economical and superior to commercial nitrogen fertilizer (ref. 15).

3.5.5 FERTILIZERS - WESTERN AUSTRALIA

Western Australia has been by far the greatest user of fertilizer in terms of quantity applied; this is consistent with the magnitude of cropping, especially of wheat. However, unlike other states, Western Australia uses a larger amount of fertilizer on improved pasture. Most of the soils of Western Australia have low inherent fertility, and without the use of fertilizers they cannot support the growth of commercial crops. Practically all soils in the southwestern part of the state need phosphorus fertilizers, which must be applied when the crop is planted. Many of the light (sandy) soils are also deficient in trace elements: copper, zinc, manganese, molybdenum. To compensate for this deficiency, small amounts of these elements are added to fertilizer mixtures for deficient soils. Nitrogenous fertilizers are commonly used and are very profitable for certain soils, especially the newly developed sandy soils. The soil is also enriched through the use of leguminous pasture plants (usually subterranean clover), which build up the soil's organic matter and moisture-holding ability over several years, and increase the amount of nitrogen available for crops. This sequence of cropping for one or more years after one or more years of a fertility-building pasture period is known as "ley farming." This is the usual system in the wheat belt. The intensity of cropping reduces, and the period of pasture between crops increases, in passing from low to higher rainfall areas.

3.5.6 DISEASES AND PESTS IN NEW SOUTH WALES

A comprehensive list of the diseases of wheat and their effects is contained in appendix C. However, the major diseases of wheat and their effects are as follows.

Take-all in Australia is likely to be serious on light or poorly compacted soils, on land that has previously been under pasture, on alkaline soils, and in areas where growing conditions are unfavorable. It has proved particularly troublesome in irrigated crops and in wheat grown on land restored to fertility by a long period under clover-grass pasture.

Stem Rust usually does not cause conspicuous damage until late in the season. It attacks all the above ground parts of the plant and is particularly serious when it develops on the upper portions of the stems during the grain-filling

period. The occurrence and severity of the disease are closely related to weather. Warm, humid weather with frequent showers and heavy dews is particularly favorable for development of rust.

Powdery Mildew of Wheat is a common disease of wheat in New South Wales, but in most seasons it does not cause sufficient damage to reduce yields. The disease is most prevalent in the winter and early spring in seasons of high rainfall. In moist, warm weather it may develop rapidly, causing appreciable damage.

Flag Smut of Wheat is a fungus. Twenty years ago it was regarded as a very serious disease of wheat in New South Wales. However, wheat varieties resistant to this disease were developed and their widespread use led to a marked decline in the incidence of flag smut. This was the case until the varieties Gabo, Gamenya, Mengavi, and Mendos were introduced. These are all susceptible to flag smut, and as a result, this disease has reappeared and is causing serious economic damage in some areas where these susceptible wheat varieties are widely grown.

Common pests to New South Wales include:

Rabbits, plague locust, feral pigs, kangaroos, emus, winged grasshoppers, wingless grasshoppers, and noxious weeds such as Bathurst and Noogoora Burr, Variegated and Saffron Thistle, Patterson's curse, fireweed and wild oats.

Some controls of these pests include:

Rabbits: controlled by the disease myxomatosis and the European Rabbit Flea.

Plague locust hatchings: ground spraying supported by aerial detection.

Feral pigs: controlled by poisoning.

Kangaroos: culling by shooting.

3.5.7 WHEAT DISEASES AND PESTS IN WESTERN AUSTRALIA

The main crop pests, red-legged earth mites, weevils, and webworms, are fairly easily controlled by insecticidal sprays, but for most economical control, spraying must be carried out before the pests have caused much damage.

Septoria, Take-all, and Stem Rust are the main diseases of wheat in Western Australia. In the higher rainfall areas, wheat yields can be considerably reduced by Septoria diseases which produce blotches and spots on the leaves, stems, and heads of wheat plants. Stubble burning and use of rotations may reduce the amount of disease carried over from one year to the next. Varieties resistant to Septoria diseases are also being developed.

Take all is a widespread root-rotting disease which is most serious in higher rainfall wheat growing districts. The heads of the wheat plant contain little or no grain. Rotations which include legumes, oats, or linseed help to reduce the incidence of the disease. There are no recognized resistant wheat varieties.

Stem Rust can cause heavy losses to wheat crops in some areas in years when it is able to survive through summer, and growing season conditions are favorable for its development and spread. Widespread losses due to rust are very rare in Western Australia. The only economical way to control it at present is to use resistant varieties. New strains of rust are continually appearing which attack varieties previously resistant.

Webworm, larval stages of four different species of moths, attack the young plants during winter. A period of fallow in summer, or at least a few weeks in autumn, helps to control them. Insecticidal sprays must be used to control them in some crops in some seasons.

Weevils are a serious problem and if not properly controlled can damage stored grain. They can live from harvest to harvest in pockets of grain left in grain storages and in grain handling machinery. They can be best controlled by completely cleaning empty storage and machinery and treating grain with special protectants.

Wild Oats is an agricultural weed that is now a problem in all Australian states. In the 1960's it became obvious that the density of wild oats increased

rapidly with multiple cereal cropping. Multiple cropping gave little opportunity for control by grazing, which reduces seed setting considerably. A wild oat infestation reduces the yield of a wheat crop, they are also considered a contaminant in harvested grain and are subject to dockage by grain handling authorities.

Control depends upon the species involved. One species is easily controlled by a single cultivation, another species requires a minimum of three prior years pasture, with regulated grazing to stop seed formation. Pre-crop cultural treatments should be designed to kill as many weeds as possible. Herbicide treatment can also be used but is unlikely to give an economical return in low-yielding crops.

3.5.8 CROPPING PRACTICES - MINIMUM TILLAGE TECHNIQUES

Fallow is confined to a proportion of the heavier soils of the wheat belt and accounts for only about 10-15 percent of the total cropped area.

Experimental work is being done on minimum tillage techniques and is being expanded as fuel and machinery costs rise. Direct drilling or minimum tillage for crop establishment is now an established commercial practice in Western Australia. The growth of interest in minimum tillage techniques is shown in the table below. This trend is expected to continue.

<u>Year</u>	<u>Hectares</u>
1971	10 000
1972	11 000
1973	28 000
1974	70 000
1975	22 000
1976	22 000
1977	25 000
1978	40 000
1979 (estimated)	100 000

Source: Western Australian
Dept. of Agriculture,
Annual Report,
June 30, 1979

The 100 000 hectares shown for 1979 represents about 700 farmers using direct drilling techniques.

3.5.9 CROP ROTATIONS

3.5.9.1 Western Australia

In Western Australia most wheat farms raise sheep or other livestock. As a result, most wheat land is subject to rotation involving some form of pasture. A paddock (field) may only be cropped for wheat, barley or oats in two of five years, and be sown to pasture for the other three. This rotation helps maintain soil fertility and resist erosion.

In lower rainfall areas many farmers continue to use a wheat-natural pasture system of cropping because in some areas, no suitable legumes are available to grow really productive pastures in some soils (ref. 2).

Lupins provide some fertility for a following cereal crop. In a pasture-crop rotation, higher yields are more likely when lupins are sown after a cereal. Broad-leafed weeds are usually better controlled, thus making the land easier to work. Problems in seeding after a legume pasture or lupin crop may occur from the possibility of severe disease attack and the greater competition from grass weeds resulting from the nitrogen build-up.

3.5.9.2 New South Wales

Ley-farming is the common practice in New South Wales, although some farmers practice wheat-fallow-fallow-wheat-grass (weed) rotation. In the past, the rapid spread of skeleton weed made changes in cropping essential. Some farmers turned to grazing, others to chemical spraying and then the adoption of the ley-farming system in which pasture plants compete with the weed. Some crop rotations include growing grain sorghum. Grain sorghum is summer grown, raised principally on the wheat lands of northern New South Wales, and extending into Queensland. It is more suitable to higher temperature climates and more drought-resistant than maize. Grain sorghum can be sown and harvested with the same equipment as that used for wheat and fits in well with crop rotation on

wheat farms. In summer-rainfall areas such as the area of Northern New South Wales on into Queensland, grain sorghum is often sown following a failure of the wheat crop, in order to supplement farm income and to meet feeding requirements during droughts. Two factors have significantly influenced the marked expansion in the area under grain sorghum: the increased availability of irrigation water and the rapidly expanding Japanese market for the grain (ref. 16).

3.5.9.3 Soils

Western Australia wheat belt soils are highly variable; they range from heavy clays and fertile loamy soils to infertile sands with very little clay in the surface soil. Most of the lighter soils are derived from lateritic (gravelly) parent material. Most of the sandy soils, despite their poor natural fertility, can be made productive through fertilizers, trace elements, and ley farming.

Figure 3-5 shows the soils in the Western Australia wheat belt (see refs. 2, 18, and 19).

3.6. ACQUISITION TIME PERIODS

Acquisition time periods needed to discern wheat and small grains:

- a. Pre-planting to pre-emergence — Late March to early May
- b. Early mid-season varieties emerging — Late June to late July
- c. Late planting, after emergence — September 15 to October 21
- d. Turning — Late October to early November
- e. Harvest — Mid-November to late December

3.7 LANDSAT DATA AVAILABILITY

Landsat data for Australia are available for past years. Historical coverage (5- by 6-nautical mile or 9- by 11-kilometer sample segment area) for Australian LACIE Phase I (1975-76) data consists of limited segment histories for eight segments in the IR. In this data set, four segments are provided for each of Western Australia and New South Wales.

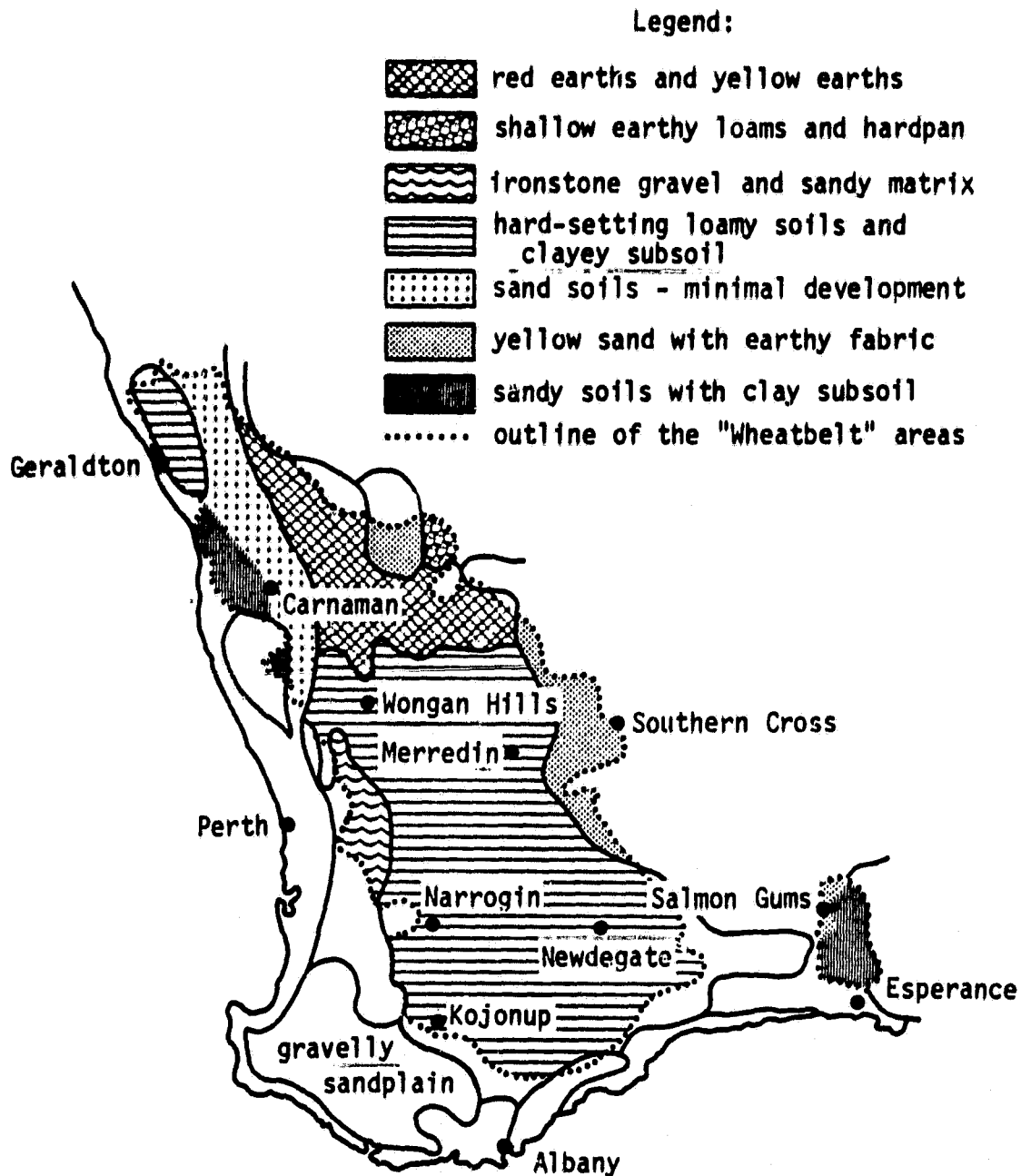


Figure 3-5.- Simplified soil map of the wheat belt of Western Australia.

The Landsat data for the 1977-78 crop year are incomplete (August 28, 1977, to January 26, 1978). The decision to include Australia within the LACIE Transition Project activities was not made until the 1977-78 crop season was well underway. Since data were not collected by the satellite prior to late August, a retroactive data order for the early part of the crop season was impossible. Confusion of the at-harvest wheat signature was a problem in many Australian segments, particularly in Western Australia and New South Wales. In many instances, the harvest signature for wheat was not as readily identified as, for example, in the United States Great Plains (USGP). To help the analyst with this at-harvest problem, the satellite was reinstated to gather information over selected sites for February and March of 1978.

Table 3-2 contains the number of sample segments allocated by state, the number of sample segments used in the TY Australia aggregation and a percentage of those allocated that were used in the TY estimate.

Satellite data were not collected again until March 1, 1979 (no data were collected for 1978-1979 crop year). These data were collected from March 1, 1979, to December 1979. The March 1, 1979, to December 1979 data set corresponds to the original 257-segment allocation.

Collection of satellite data for the 1980-81 crop year has been underway since January 1, 1980 (fig. 3-6). The data set being collected is different from the previously collected set in that 88 segments are being collected in New South Wales and 49 segments in Western Australia. Of these, 27 segments cover coordinates supplied by the Australians as potential ground-truth collection sites in New South Wales only. The 1981-82 Landsat data order consists of 147 sample segments obtained for Western Australia and New South Wales combined (98 in New South Wales and 49 in Western Australia). Reference 20 contains the actual segment numbers and geographical locations.

A summary of the Landsat data available appears in table 3-3.

TABLE 3-2.- 1977-78 TRANSITION YEAR ESTIMATES

State	Sample segments allocated	Sample segments used	Allocated segments used in estimate, %
Mid-season estimates ^a			
New South Wales	125	81	65
Western Australia	49	12	24
Queensland	16	14	88
South Australia	23	(c)	
Victoria	44	11	25
Total ^d	257	118	46
Late-season estimates ^b			
New South Wales	125	113	90
Western Australia	49	32	65
Queensland	16	16	100
South Australia	23	(c)	
Victoria	44	30	68
Total ^d	257	191	74

^aBased on Landsat data acquired prior to Nov. 1, 1977.

^bIncludes Landsat data acquired through January 26, 1978.

^cInsufficient Landsat data to support aggregation; estimates generated using a historical ratioing procedure.

^dTotal may not add due to rounding.

TABLE 3-3.- SUMMARY OF LANDSAT SEGMENT DATA

Crop year	State	Number of segments allocated	Number of segments received (as of 4/81)	Average* number of acquisitions received per/segment received
1975-1976	New South Wales	<i>Exploratory sites</i>	4	4.25
	Queensland		2	3.50
	South Australia		2	2.50
	Victoria		2	5.50
	Western Australia		4	2.50
Total	5 States		14	
1977-1978	New South Wales	125	125	7.42
	Queensland	16	16	7.88
	South Australia	23	23	2.74
	Victoria	44	44	5.41
	Western Australia	49	49	6.16
Total	5 States	257	257	
1978-1979	No data collected			
1979-1980	New South Wales	125	125	9.61
	Queensland	16	16	10.81
	South Australia	23	23	3.43
	Victoria	44	44	5.09
	Western Australia	49	49	6.37
Total	5 States	257	257	
1980-1981	New South Wales	88	87	5.41
	Western Australia	43	42	3.24
Total	2 States	131	129	
1981-1982	New South Wales	98	Not available at this time	
	Western Australia	49		
Total	2 States	147		

*does not reflect the typical segment

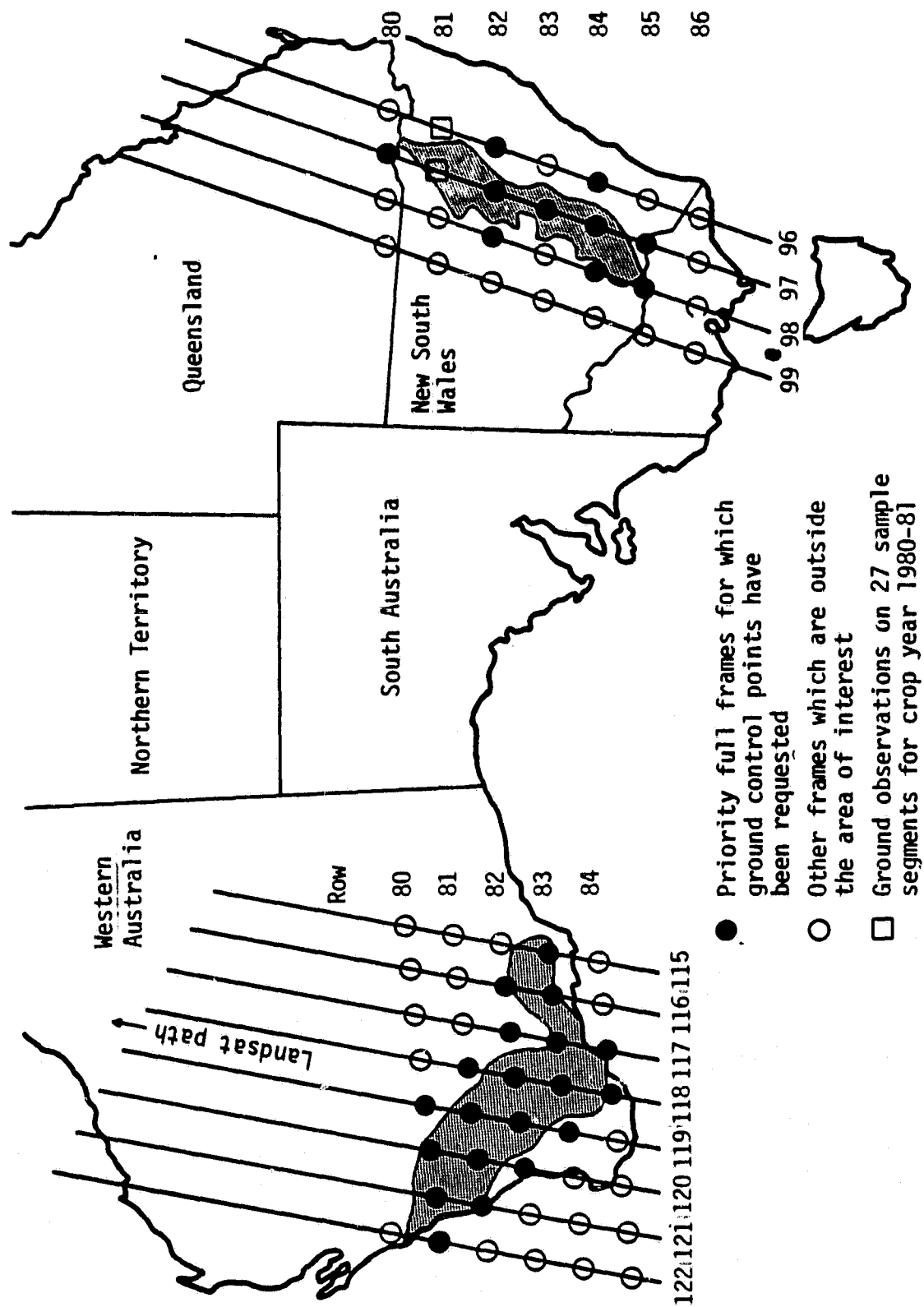


Figure 3-6.- Australian full frames, 1980-81.

3.8 GROUND OBSERVATIONS IN AUSTRALIA (TABLE 3-4)

During LACIE Transition-Year processing (1977-78 crop year) of Australia, it was determined that an agricultural experiment farm was within sample segment 4042. This prompted project personnel to initiate the action to establish a liaison with Australian agronomists for collecting these ground-truth data.

Ground-truth data for sample segment 4042, Timbregongie Shire, New South Wales, Australia, were collected for crop year 1977-78. The data were collected by Ken W. Dawbin, Remote Sensing Officer (Research and Interpretation), through E. K. Leggett, Principal Officer of Remote Sensing, Department of Agriculture, New South Wales, Australia. He provided detailed sketches of the fields within the sample segment, information covering crop type, irrigation, seeding rates, and planting dates.

Extensive use of these ground observations was made in identifying technical issues to be addressed prior to processing Australian data during the AgRISTARS program. A summarization and consolidation of various Australian special studies and investigations that have been conducted upon completion of LACIE is contained in reference 5.

Ground data were obtained for six sites in New South Wales in the 1979-80 crop season. These are being processed for use in the AgRISTARS program. Twenty-seven segment locations over ground observation points provided by the Australians were located for data collection in the 1980-81 crop season. However, these ground observations have not been obtained from the Australians at this time.

Ground observations in Western Australia for crop year 1980-81 were collected by Bill Dowdy (USDA), Don Henninger (NASA), and Dave Nichols (LEMSCO) in late October and early November 1980. These observations were collected over fields along major roads in a subset of seven Western Australia sample segments.

A plan is underway to collect ground observations as part of the AgRISTARS program for crop year 1981-82 in October and November 1981.

TABLE 3-4.- GROUND OBSERVATIONS, AUSTRALIA

a. Observations for 1977-81

1977-78		1979-80		1980-81	
Segment	Location	Segment	Location	Segment	Location
4042	Timbreebongie Shire, New South Wales, Australia	4013	New South Wales	4408	Western Australia
		4015	New South Wales	4412	Western Australia
		4016	New South Wales	4416	Western Australia
		4030	New South Wales	4419	Western Australia
		4033	New South Wales	4423	Western Australia
		4042	New South Wales	4425	Western Australia
				4427	Western Australia
		4500 to 4526	New South Wales*		

*To date, no ground-observed data have been received.

b. Proposed observations for 1981-82

Segment	Location	Segment	Location
4408	Western Australia	4013	New South Wales
4410	Western Australia	4015	New South Wales
4412	Western Australia	4016	New South Wales
4416	Western Australia	4030	New South Wales
4419	Western Australia	4033	New South Wales
4423	Western Australia	4036	New South Wales
4425	Western Australia	4037	New South Wales
4427	Western Australia	4038	New South Wales
4422	Western Australia	4042	New South Wales
		4095	New South Wales
		4104	New South Wales

3.9 RELATIONSHIP OF CLIMATE TO LABELING ACCURACY AND PROPORTION ESTIMATION

A drought can affect labeling in several ways, depending on when the problem occurs and its severity and duration. Stored moisture must be available from summer and fall rains in New South Wales in order for normal plant growth (in June and July) and stand density to be realized. If the rains do not occur on time, farmers will delay plowing, preparation, and planting until after the rains. Rainfall is also needed during the spring months from August through November when the crop is progressing from jointing through grain filling, when the yield would be affected. A combination of drought and high temperatures would increase the water requirements for the wheat crop. Wheat under moisture stress would show an accelerated development (ref. 4).

In Western Australia, most of the precipitation occurs in the winter months of June through September while the wheat is actively growing. If this rain does not occur as normal, the result is a decline in vegetative signatures.

A locally developed transformation of the Landsat digital data, the green index number (GIN), was used in the TY to assess the spectral data for indications of moisture stress. The GIN data were used to generate a map of Australia depicting areas of adequate moisture and regions with vegetation undergoing stress (fig. 3-7). The results correlate well with a 1977 rainfall deficiency map prepared by the Australian Bureau of Meteorology (fig. 3-8). See references 4 and 5.

AUSTRALIA

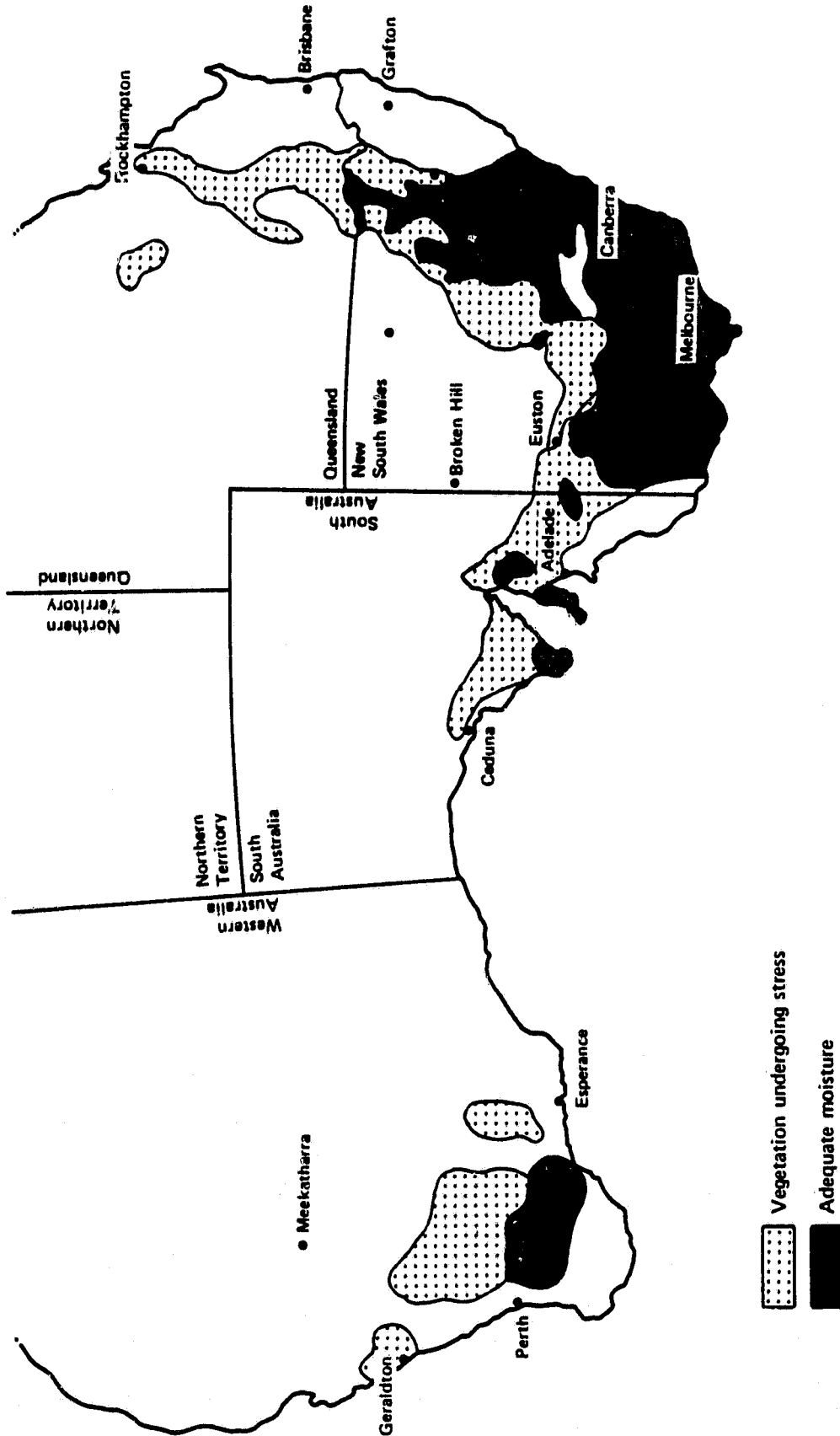


Figure 3-7.- Stress area delineated by GIN (refs. 4 and 5).

AUSTRALIA

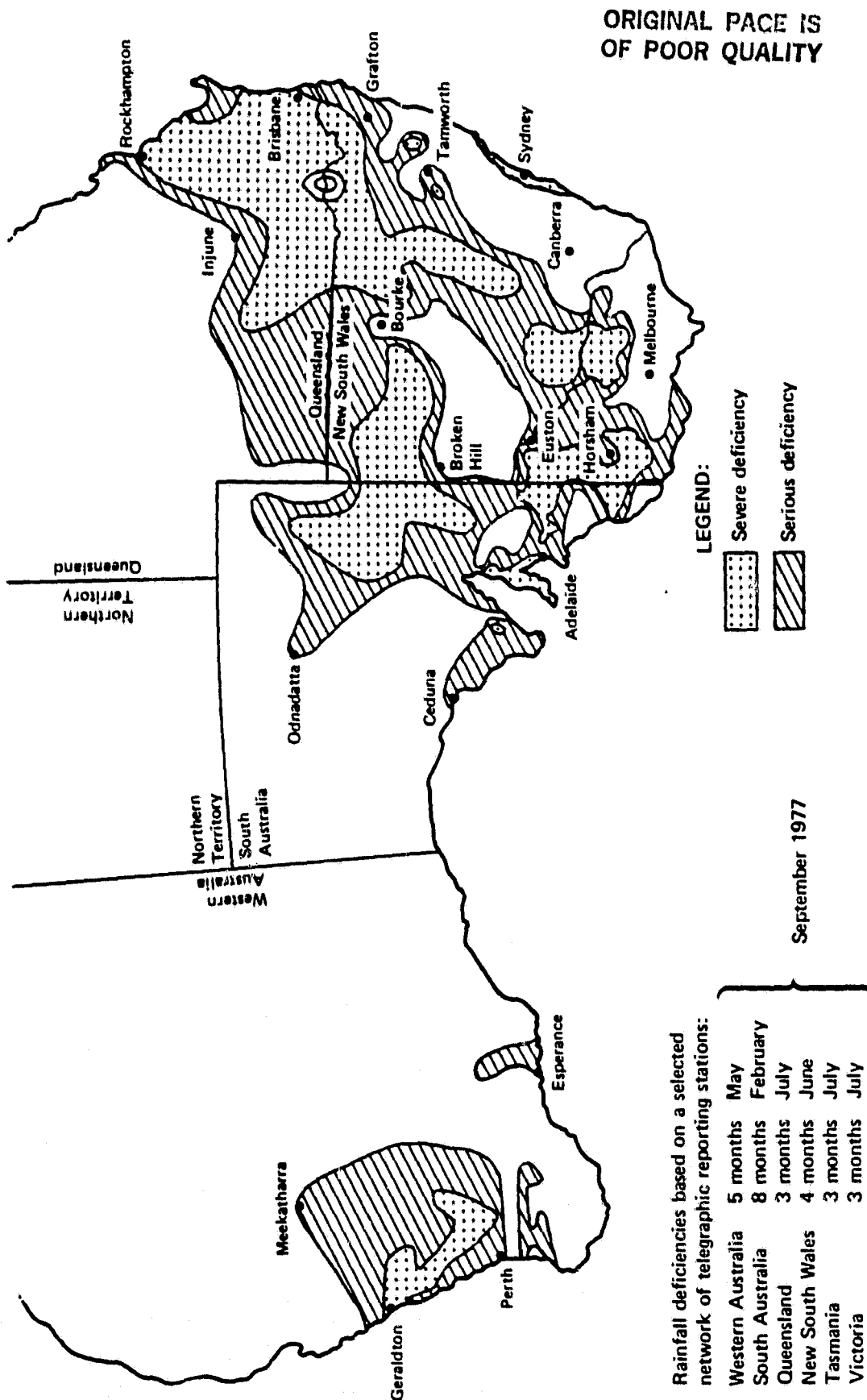


Figure 3-8.- Areas of rainfall deficiencies (refs. 4 and 5).

APPENDIX A
SOURCES OF DATA

APPENDIX A

SOURCES OF DATA

A.1 AVAILABILITY AND SOURCES OF STATISTICAL DATA

A.1.1 NEW SOUTH WALES

For New South Wales, the official year-end crop statistics are published twice each year in two different publications, once in February and again in September (refs. 21 and 22).

For this state, the shire is the smallest political level for which statistics are available. The measurement units for the statistics are as follows: area — hectares (planted area only); yield — not reported (as such, yield is a derived yield obtained from area and production); and production — metric tons.

A.1.2 WESTERN AUSTRALIA

For official year-end crop statistics for Western Australia, see references 23 and 24. These statistics are compiled primarily from statutory returns supplied annually on March 31 by operators of rural holdings in Western Australia. A copy of the agricultural census return which is used is given in the back of the statistical publication.

In previous years, other statistical publications were printed, but these appear to have been phased out (refs. 22 and 24). They were as follows:

- a. "New South Wales Statistical Register, Rural Industries and Settlement and Meteorology 1969-70 and 1970-71," Bureau of Census and Statistics, Sydney.
- b. "Statistics of Western Australia, Rural Industries."
- c. "Statistics of Western Australia Non-Rural Primary Industries."

The last of the two documents cited (b and c) are no longer published and were replaced by the document "Statistics of Western Australia, Agriculture, Forestry, Fishing, and Hunting", which was first published in 1974-75 (ref. 23).

For Western Australia, the shire is the smallest political subdivision level for which statistics are available. The measurement units used for the statistics are as follows: area — hectares (planted area only); yield — metric tons/ha; and production — metric tons.

A.2 METHODS OF REPORTING AND RELIABILITY OF AUSTRALIAN STATISTICAL DATA¹

Australian agricultural data are reported at a state and commonwealth (country) level. The State Wheat Boards, the State Departments of Agriculture, and the Australian Bureau of Statistics all independently prepare commonwealth-level statistics.

A census approach is used to contact the individual wheat growers. Each March, a complete census is conducted for the previous year and includes data on growers' intentions for the coming season. State office sample surveys are conducted also in July, August, and October. With respect to accuracy, there are no field checks and the agricultural census summation is a few percent low compared to actual silo loadings. State-level statistics are estimated by the various State Departments of Agriculture and the State Offices of the Australian Bureau of Statistics.

In New South Wales, the main goal of the season reporting is to obtain the wheat production estimate. The district advisors cover one to three shires, talking to farmers and driving through the region with the Wheat Board representatives. The Wheat Board estimates are considered to be more conservative than the Department estimate. The estimated percent for harvest is not widely published but is made in October and is collated and analyzed by the Department of Marketing and Economics. A plan to field survey harvested areas is under consideration. At this time, though, harvested acreage is not reported in the statistical publication previously mentioned.

¹Information contained in this subsection is based on findings from available Australian crop data by Bryan Erb, NASA/JSC, on his May 1979 visit to Australia.

For Western Australia, there is some local collection of area and yield data by district advisors. These data are considered to be highly subjective in nature.

A.3 NONSTATISTICAL DATA

Through the National Agricultural Library in Beltsville, Maryland, a data search was done on the Agriculture On-Line Access (AGRICOLA) data base (ref. 25).

This data base contains data on world agriculture. Access was obtained through the NASA/JSC Technical Library at the National Aeronautics and Space Administration (NASA), Johnson Space Center (JSC). Unfortunately, the AGRICOLA data base contained a rather limited amount of data on Australia, and only seven articles were received through interlibrary loan (ref. 25).

APPENDIX B
WHEAT VARIETIES

APPENDIX B

WHEAT VARIETIES

B.1 SILO GROUPINGS AND WHEAT VARIETIES FOR NEW SOUTH WALES

Recommendations for wheat varieties for New South Wales are given according to grades by silo groupings (see references 10, 12, 13, 14, 26, and 27). Three Durum varieties, T. Durum, are recommended for New South Wales subject to license by the Australian Wheat Board or under contract to Fielder Gillespie, Limited, Tamworth. The New South Wales wheat growing region is divided into six silo groupings (see figure B-1). The following groups are the recommendations for the IR's for 1979.

B.1.1 SILO GROUPINGS

Silo Group 1

In this area, the Prime Hard varieties are Cook, Gatcher, Shortim, Songlen, Timgalen, and Timson. The Northern Hard varieties are the same as the prime hard varieties, with the addition of Kite, which is received subject to availability of segregation and storage for "Northern Hard" class. The Australian Standard White varieties are the same as those varieties mentioned in the "Northern Hard" class. No varietal discount is given to the varieties in the Prime Hard, Northern Hard, and Australian Standard White classes.

Subject to assessment, varietal discounts may be applied by the Australian Wheat Board to all varieties not listed above, including Condor, Eagle, Egret, Jabiru, Olympic, Teal, and any unregistered crossbred.

Silo Group 2

Classes and varieties recommended for this silo grouping are the same as those given for Silo Group 1.

B-2

Silo Group 3

In this area, the Prime Hard varieties are Cook, Gatcher, Shortim, Songlen, Timgalen, and Timson. The Southern/Western Hard class includes Condor, Cook, Eagle², Gatcher, Kite, Shortim, Songlen, Timgalen, and Timson. The preferred Australian Standard White varieties are Condor, Cook, Gatcher, Kite, Shortim, Songlen, Timgalen, and Timson. Eagle will also be accepted until more suitable varieties are released.

Subject to assessment by the Australian Wheat Board, varietal discounts may be applied to all varieties not previously listed, including Egret, Jabiru, Olympic, Teal, and any unregistered crossbred. No varietal discount is given to the varieties listed under Prime Hard, Southern/Western Hard, or Australian Standard White varieties listed above.

Silo Group 4

In this area the Southern/Western Hard class recommended varieties include Condor and Kite. The following varieties are also included, but they may be of low yield potential in the districts of Cook, Gatcher, Shortim, Songlen, Timgalen, and Timson. The preferred Australian Standard White varieties are Condor, Kite, Olympic, and Teal. Also accepted are Egret and the varieties mentioned above as being of potential low yield in these districts.

A varietal discount subject to assessment may be applied by the Australian Wheat Board to all varieties not listed above, including Eagle and any unregistered crossbred.

Silo Group 5

In this area, the soft wheat varieties recommended are Egret, Olympic, and Teal. The preferred Australian Standard White varieties are also Egret, Olympic, and Teal. Also accepted are Condor and Jabiru. Jabiru has a low yield potential in these districts.

² This recommendation is temporary; pending release of more suitable varieties, it is slowly being phased out.

APPENDIX C

DISEASES AND PESTS COMMON TO NEW SOUTH WALES, AUSTRALIA

APPENDIX C

DISEASES AND PESTS COMMON THE NEW SOUTH WALES, AUSTRALIA

The following descriptions of the diseases and pests common to New South Wales were excerpted from plant disease bulletins published by the Biology Branch, Biological and Chemical Research Institute, New South Wales Department of Agriculture.

Take-All of Wheat - Take-all is a root and crown rot disease. The most typical symptoms of the disease are premature death of plants after heading and before grain matures. The disease occurs in patches, and infected plants are stunted, tillering is reduced, and the ears ripen prematurely. Such plants produce either badly pinched grain or no grain at all. The empty, bleached ears are called "whiteheads." The roots of infected plants are rotted and dark brown to black. This discoloration usually spreads one to two inches up the stems. Take-all can occur during the early stages of crop growth. In this case, more or less circular patches of yellowed, stunted plants occur.

Symptoms of take-all often become noticeable following hot, drying winds when the diseased root system cannot supply water at the rate it is being lost. Sometimes symptoms are confused with frost injury.

Take-all is caused by soil-inhabiting fungus, *gaeumannomyces graminis*. This fungus can also attack barley and many grasses. It lives in the soil on infected stubble or on the roots of naturally occurring grasses. In the absence of living hosts the fungus dies within a year and although no varieties resistant to take-all are available, it can be controlled with long fallows or by growing an immune crop such as oats or linseed.

In Australia, take-all is likely to be serious on light or poorly compacted soils, on land that has previously been under pasture, on alkaline soils, and where growing conditions are unfavorable. It has proved particularly troublesome in irrigated crops and in wheat grown on land restored to fertility by a long period under clover-grass pasture.

Control - If take-all becomes troublesome, losses can be minimized by growing an immune crop such as oats or linseed for one season. Weed-free fallow periods of at least 6 months can also be used to starve the fungus out of the soil. Finally, wheat or barley should never be used as first crops on new land. If an immune crop such as oats or linseed is grown first, then losses from take-all in subsequent wheat crops are much reduced.

Stem Rust of Wheat - Stem rust, caused by the fungus *puccinia graminis tritici*, has probably caused greater and more spectacular damage than any other wheat disease.

Stem rust usually does not cause conspicuous damage until late in the season. It attacks all the above-ground parts of the plant and is particularly serious when it develops on the upper portions of the stems during the grain-filling period.

In the early stages the disease is characterized by reddish-brown, powdery, oblong pustules on the leaves and stems, and even on the glumes. These pustules may appear at any stage of plant growth and are composed of masses of microscopic spores which blow about and spread the disease. Later in the season the pustules go black, owing to the production of the black resting spores of the fungus. These black spores are not important in the survival of the fungus in New South Wales.

The occurrence and severity of the disease are closely related to weather. Warm, humid weather with frequent showers and heavy dews is particularly favorable for development of rust.

Control of rust by chemical sprays is uneconomic at the present time. Control of this disease at present depends on the development and use of resistant varieties. Unfortunately, the rust fungus is very variable, and, from time to time, new races arise which are able to attack varieties previously resistant to all races present.

For this reason, no long-term recommendations on resistant varieties can be made. Information as to the resistance of current varieties can be obtained from the Department of Agriculture district agronomists.

Powdery Mildew of Wheat - Powdery mildew is a common disease of wheat in New South Wales but in most seasons, it does not cause sufficient damage to reduce yields. The disease is most prevalent in the winter and early spring in seasons of high rainfall. In moist, warm weather it may develop rapidly in rank portions of crops and cause appreciable damage.

Powdery mildew is usually confined to the lower leaves of wheat but, under favorable conditions, it occurs on young leaves, leaf sheaths, stems, and ears. Leaves show early symptoms of more-or-less extended patches of white or pinkish-white cottony growth which turns a grayish to grayish-purple color. Severely infected leaves turn yellow and ultimately wither and die. A similar cottony growth may appear on the ears if high rainfall occurs in spring and early summer. Infected ears are reduced in size, and may be distorted; in bearded varieties, the awns are often reduced or suppressed.

Powdery mildew also occurs on other cereals but the strains on other plants are distinct from the form that attacks wheat. Thus, cross-infection between different cereals does not occur.

Control - Control measures are rarely necessary for powdery mildew. However, if a crop is growing too rankly, feeding off in June or July will reduce the flag and thus minimize damage if the spring is warm and moist.

Technical Detail - The fungus *erysiphe graminis tritici* causes powdery mildew of wheat. This fungus produces large numbers of spores on the cottony mass of fungal growth on infected wheat leaves, stems, and ears. The spores are spread by wind and rain and under favorable conditions, produce new infections throughout the crop and on surrounding wheat crops.

Later in the season, the cottony mass on infected tissue turns a gray to grayish-purple color. Numerous small, spherical, black bodies develop in the weft of fungal threads on all infected plant parts. These structures contain resting spores which enable the pathogen to survive from season to season.

Loose Smut of Wheat - Loose smut of wheat is caused by the fungus *Ustilago nuda* and is quite distinct from other smut diseases which occur on wheat, other cereals and grasses.

Symptoms of this disease are obvious as soon as wheat comes into ear. Infected heads are distinguished by the black, sooty powder which replaces the grain and chaff. This powder is composed of spores of the fungus which are readily scattered by the wind so that eventually only the central axis of the head is left.

The spores may become lodged on the flowering parts of adjacent healthy wheat heads where, if conditions are humid, they may germinate and grow into the developing grain. When the fungus is thus established in the young wheat grain, it passes into a resting condition in the embryo. The grain then develops into a seed of normal appearance.

Although these grains appear normal, they will give rise to infected plants in the next season. After germination of the grain, the threads of the fungus grow in the tissues of the developing plant, keeping pace with its development; and at heading time, some or all the ears are replaced by smut spores.

Because the parasite is inside the embryo of the wheat seed, it is protected from fungicidal dusts. Fungicides used in seed treatment are ineffective in controlling loose smut. The spores of some other smuts of cereals and grasses are carried externally on the seed surface and, therefore, are readily killed by fungicidal dusts.

Control - Control of the loose smut depends on the use of seed wheat from a crop grown in an area where no loose smut has occurred. Seed can be

freed of infection by a hot water treatment. However, this treatment requires special equipment to maintain rigid temperature control and can only be applied to small quantities of seed. The method is impractical for general use by farmers but the Department of Agriculture uses it during the production of mother seed for supply to registered seed growers. If this disease is proving troublesome, it is best controlled by obtaining fresh seed from a source known to be free from the disease.

Flag Smut of Wheat - Twenty years ago flag smut, caused by the fungus *Urocystis agropyri*, was regarded as a very serious disease of wheat in New South Wales. However, wheat varieties resistant to this disease were developed and their widespread use led to a marked decline in the incidence of flag smut. This remained the position until the varieties Gabo, Gamenya, Mengavi, and Mendos were introduced. These are all susceptible to flag smut, and as a result, this disease has reappeared and is causing serious economic damage in some crops in areas where these susceptible wheat varieties are widely grown.

Flag smut is evident from the late seedling stage until the crop reaches maturity. The disease is first evident on the leaf blades and sheaths as elongate, dull white stripes which soon become gray and eventually become grayish-black on older leaves. It is in these stripes that the masses of smut spores are produced.

Infected plants are often stunted, the leaves are not a normal green, and the plants frequently fail to produce heads. As infected plants approach maturity, the abnormally gray flag becomes twisted and distorted.

These plants are broken up during harvest and many of the spores find their way into the soil or adhere to healthy grain. If another wheat crop is sown in contaminated soil, seedlings, at the time of germination, may come in contact with spores and thus become infected. Similarly, infection may occur if seed contaminated with flag smut spores is sown in clean soil.

Control - While routine chemical treatments will control the spores adhering to the grain, they do not give adequate protection to seedlings growing in infected soil. If the disease appears on a property, only resistant wheat varieties should be grown there. Most varieties recommended for planting in New South Wales are resistant or moderately resistant. The exceptions are the susceptible varieties Gamenya, Mendos, and Gamut. Gabo and Mengavi, which are no longer recommended, are also highly susceptible.

Downy Mildew of Cereals and Grasses - Downy mildew of cereals and grasses is caused by a number of parasitic fungi, one of the most common being *phytophthora macrospora*. In New South Wales this fungus has been recorded as infecting oats, wheat, maize, rice, sorghum, and a number of grasses. The name downy mildew, by which it is generally known overseas, has been applied to it because of the downy growth sometimes produced on infected plants by some members of this group. This is not a feature of the disease in New South Wales. Other names sometimes used are crazy top, curly top, and green ear.

The most characteristic symptoms of infection are stunting and distortion. The stunting results from a shortening of the internodes, especially towards the apex of the plant. The distortion is most noticeable when it affects the panicles, which become severely twisted and misshapen. Other symptoms are a reduction of leaf size with the leaves becoming stiff and erect and the color being paler than normal. Leaves and leaf-sheaths become noticeably roughened as infected plants approach maturity. This roughening results from the production in the leaf tissues of masses of resting spores of the casual fungus.

Although downy mildew is widespread on cereals and grasses, its occurrence is only sporadic. Very little is known about how or when infection occurs although the sporadic occurrence of the disease indicates that quite specific environmental conditions are needed for this to take place. It is known, however, that moist soil is necessary for infection and for this reason, downy mildew is more common under irrigation.

Control - Control of the disease is very difficult because the fungus produces resistant resting spores in diseased tissues which eventually find their way into the soil. These resting spores can remain in the soil in the absence of hosts for at least 5 years, so crop rotation is only of limited value. Also, downy mildew can attack a very wide range of cereals and grasses, and this feature of the disease also limits the usefulness of crop rotation. Stubble of infected crops should be burned wherever possible to reduce the numbers of resting spores collecting in the soil and thus help reduce the incidence of the disease in future seasons.

Downy mildew is potentially a serious disease of irrigated crops and its occurrence should be watched for under these conditions. Any suspect plants should be sent to the Department of Agriculture for examination.

Earth Mites - The red-legged earthmite *halotydeus destructor* is found in plains, slopes, and tableland districts of the southern half of New South Wales. The blue oat mite *pentaleus major*, which can be distinguished from the red-legged earth mite by the small red spot on its back, is more widespread in the state.

Both species are active only during winter. Eggs hatch after the first autumn rains and, under favorable conditions, pass through a succession of generations and build up to large populations. With the advent of rare weather during October, the mites die off and damage ceases.

The mites infest a wide range of plants, including lucerne, clovers, peas, young cereal crops, linseed, rape, many vegetable and ornamental plants, and broad-leaved weeds.

APPENDIX D

WESTERN AUSTRALIA WHEAT GROWING REGIONS AND
NEW SOUTH WALES CEREAL GROWING REGIONS

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D.1 WHEAT GROWING REGIONS OF WESTERN AUSTRALIA

The Wheat Belt of Western Australia can be divided into nine regions (fig. D-1). Each region is based generally on average annual rainfall, and recommendations for the wheat varieties that should be grown in the area are provided. Figure D-2 shows the eight agricultural regions of New South Wales.

Region 1 (Northern Area)

The northern area lies generally north of a line through Eneabba, Carnamah, and Caron. In this area, use of rust resistant varieties depends on the risk of rust. This risk is increased if rust can be found on green plants in late summer or early autumn.

Region 2 (West Midlands)

The west midlands area is west of the Midland railway approximately between Eneabba and Gingin, where average annual rainfall is more than 450 mm. Septoria is a major problem in this area, and the main requirement is a variety which withstands this disease.

Region 3 (Central and North Central Medium Rainfall Area)

The central and north central medium rainfall area (325 to 450 mm) produces mainly ASW grade, with some Hard grade to the east and north.

Region 4 (Central and North Central Low Rainfall Area)

The central and north central low rainfall area, generally with less than 325 mm rainfall, produces mainly ASW wheat but is the major area for production of Hard grade wheat.

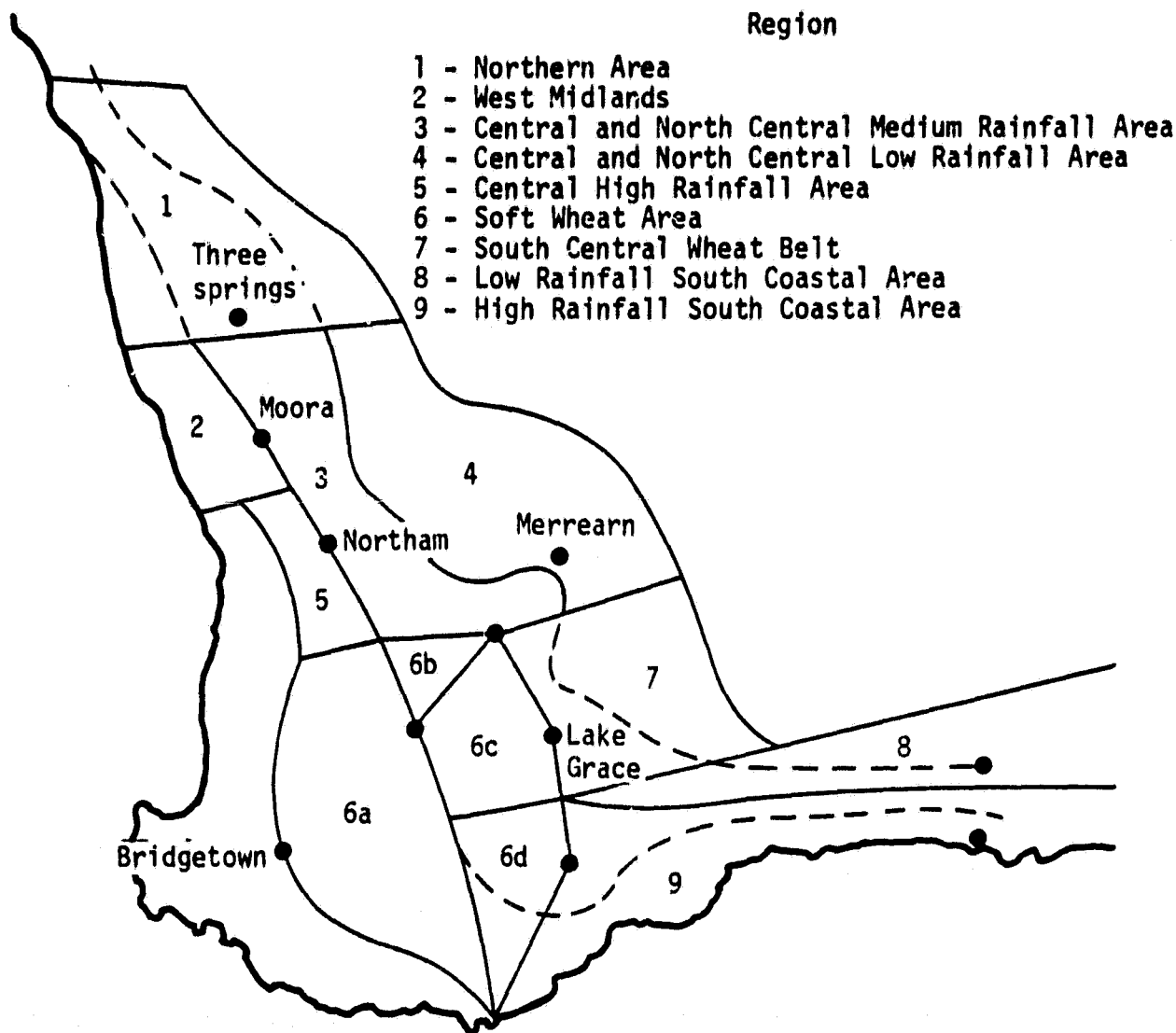


Figure D-1.- Wheat growing regions in Western Australia.

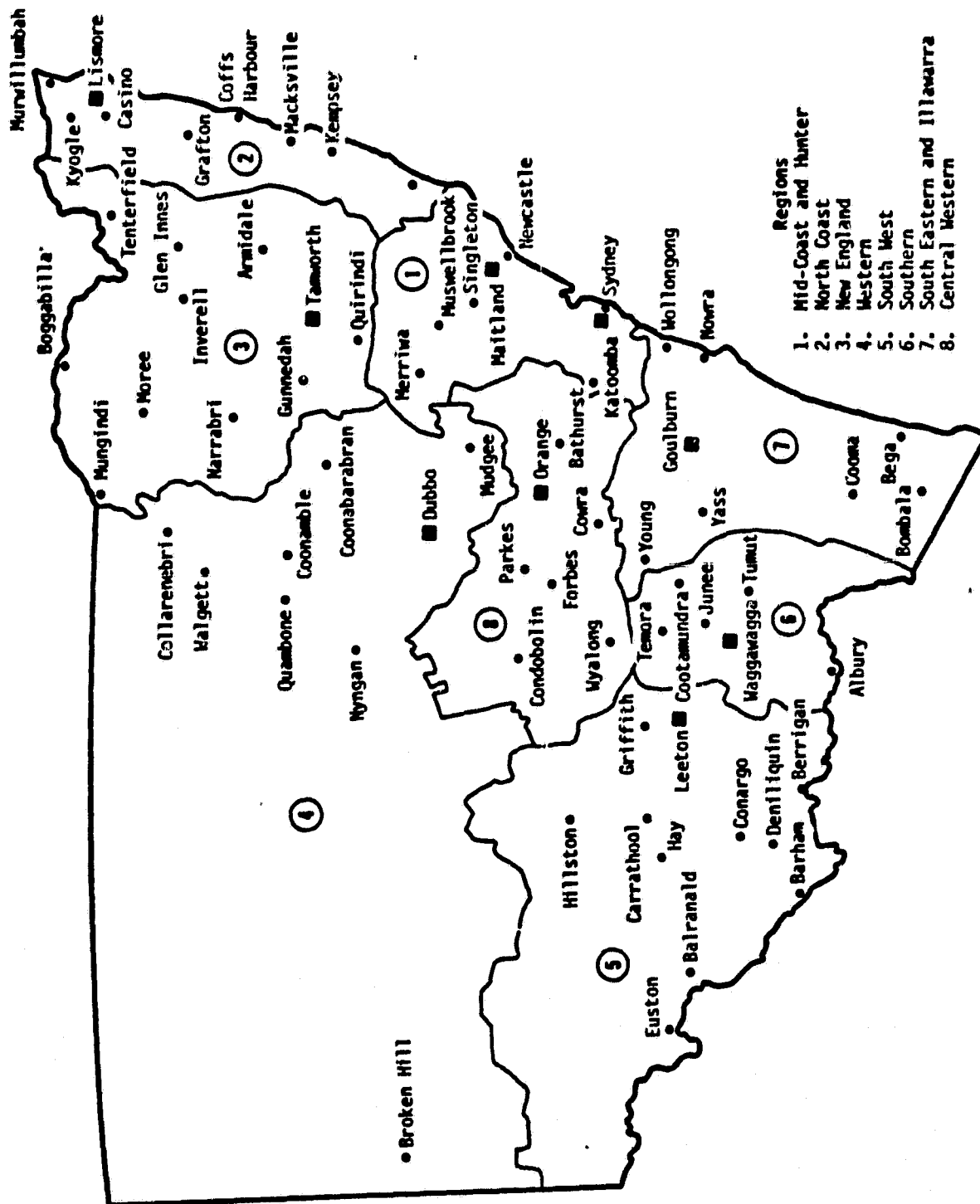


Figure D-2.- Map showing the eight agricultural regions of New South Wales.

Region 5 (Central High Rainfall Area)

The central high rainfall area, with more than 450 mm rainfall, is generally west of a line from Bolgart to Brookton.

Region 6 (Soft Wheat Area)

The soft wheat area is defined as lying south and west of a line joining Brookton, Corrigin, Lake Grace, Ongerup, and Albany. The area is subdivided into west of the Great Southern line, the original soft wheat area within the Brookton-Corrigin-Narrogin triangle, the south central medium rainfall area, and the southern rust-labile area within the area Katanning-Pingrup-Ongerup-Albany. The soft wheat area generally produces lower protein wheat and is eminently suited to the production of soft grade wheat. Available markets for this type of wheat are limited at present and future development of this trade will determine expansion of production in the area.

Region 7 (South Central Wheat Belt)

The south central wheat belt has less than 350 mm rainfall and has the approximate boundary of Corrigin, Lake Grace, Pingrup, east Mt. Madden, and east Mt. Walker. It is generally unsuitable for production of soft or hard grade wheat and is not considered rust liable.

Region 8 (Low Rainfall South Coastal Area)

The low rainfall south coastal area is classed as rust liable and receives less than 350 mm of total annual rainfall. The area is north of a line from Grass Patch to Pingrup and generally south of a line from Pingrup and Mt. Madden to Kumarl.

Region 9 (High Rainfall South Coastal Area)

The high rainfall south coastal area which is also rated rust liable has over 350 mm rainfall and is generally south of a line from Grass Patch to Pingrup, and east of a line from Pingrup to Ongerup and Albany. This adjoins the soft wheat area.

APPENDIX E

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APPENDIX E

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